Engineering Procurement and Construction (EPC)

Agreement

For

Construction of 3-Lane Bi-Directional Road Underpass on Bellary Road between Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU) Campus, Bengaluru on EPC Mode.

Bangalore Development Authority (BDA)

Government of Karnataka

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Part I

Preliminary

Engineering, Procurement and Construction Agreement

THIS AGREEMENT[1] is entered into on this the …….. day of ……., 20…..

Between

[The Government of Karnataka represented by:

……., Bangalore Development Authority (BDA), Bangalore Development Authority precincts, 5th Main Rd, Kumarapark West, Kumara Park West, Guttahalli, Bengaluru, Karnataka 560020/ …….. (hereinafter referred to as the **"Authority"** which expression shall, unless repugnant to the context or meaning thereof, include its administrators, successors and assigns) of **One Part**;

And

<insert name of party>,[2] the selected bidder[3] having its registered office at <insert registered office address of the party>, (hereinafter referred to as the "**Contractor**" which expression shall, unless repugnant to the context or meaning thereof, include its successors and permitted assigns) of the **Other Part**.

Whereas:

Government of Karnataka entrusted Construction of 3-Lane Bi-Directional Road Underpass on Bellary Road between Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU) Campus, Bengaluru on EPC Mode. [5] to the Authority;

A. The Authority resolved to Construction of 3-Lane Bi-Directional Road Underpass on Bellary Road between Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU) Campus, Bengaluru on EPC Mode in accordance with the terms and conditions to be set forth in an agreement to be entered into.

B. The Authority accordingly invited the proposals (the "**Request for Proposals**" or "**RFP**") from the eligible bidders as per the technical and commercial terms and conditions prescribed in the RFP for undertaking the Project.

C. After evaluation of the bids received, the Authority accepted the bid of the selected bidder and issued its Letter of Acceptance No. <insert details> dated <insert date> (hereinafter called the "**LOA**") to the selected bidder for [rehabilitation and augmentation of the above section of at the Contract Price specified hereinafter, requiring the selected bidder to inter alia:

(i) to give his consent to enter into this Agreement and the enforceability of the provisions thereof, within 10 (ten) days of the date of issue of LOA;

(ii) submit Performance Security and Additional Performance Security (if any) as per RFP requirements, and

(iii) execute this Agreement within 30 (thirty) days of the date of issue of LOA.

D. The Contractor has fulfilled the requirements specified in Recital (D) above;

NOW, THEREFORE, in consideration of the foregoing and the respective covenants set forth in this Agreement, the sufficiency and adequacy of which is hereby acknowledged, the Authority hereby covenants to pay the Contractor, in consideration of the obligations specified herein, the Contract Price or such other sum as may become payable under the provisions of the Agreement at the times and in the manner specified by the Agreement and intending to be legally bound hereby, the Parties agree as follows:

Article 1

Definitions and Interpretations

1.1 Definitions

(i) The words and expressions beginning with capital letters and defined in this Agreement shall, unless the context otherwise requires, have the meaning ascribed thereto herein, and the words and expressions defined in the Schedules and used therein shall have the meaning ascribed thereto in the Schedules.

(ii) In this Agreement, the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

"**Accounting Year**" means the financial year commencing from the first day of April of any calendar year and ending on the thirty-first day of March of the next calendar year;

"**Advance Payment**" shall have the meaning set forth in Clause 19.2;

"**Affected Party**" shall have the meaning set forth in Clause 21.1;

"Affiliate" means, in relation to either Party {and/or Members}, a person who controls, is controlled by, or is under the common control with such Party {or Member} (as used in this definition, the expression "control" means, with respect to a person which is a company or corporation, the ownership, directly or indirectly, of more than 50% (fifty per cent) of the voting shares of such person, and with respect to a person which is not a company or corporation, the power to direct the management and policies of such person, whether by operation of law or by contract or otherwise);

"Agreement" means this Agreement, its Recitals, the Schedules hereto and any amendments thereto, or any supplementary agreement made in accordance with the provisions contained in this Agreement;

"Applicable Laws" means all laws, brought into force and effect by the GOI or the State Government including rules, regulations and notifications made thereunder, and judgements, decrees, injunctions, writs and orders of any court of record, applicable to this Agreement and the exercise, performance and discharge of the respective rights and obligations of the Parties hereunder, as may be in force and effect during the subsistence of this Agreement;

"Applicable Permits" means all clearances, licences, permits, authorisations, no objection certificates, consents, approvals and exemptions required to be obtained or maintained under Applicable Laws in connection with the construction, operation and maintenance of the Project Road during the subsistence of this Agreement;

"**Appointed Date**" means the date declared by the Authority as the project commencement date with the consent of the contractor, as per the process prescribed in Article 3 and 8 of this Agreement;

"Arbitration Act" means the Arbitration and Conciliation Act, 1996, with all its subsequentamendments;

"Authority" shall have the meaning attributed thereto in the array of Parties hereinabove as set forth in the Recitals;

"Authority Default" shall have the meaning set forth in Clause 23.2;

"Authority's Engineer" shall have the meaning set forth in Clause 18.1;

"Authority Representative" means such person or persons as may be authorised in writing by the Authority to act on its behalf under this Agreement and shall include any person or persons having authority to exercise any rights or perform and fulfil any obligations of the Authority under this Agreement;

"Bank" means a bank incorporated in India and recognized by the Reserve Bank of India

"Base Rate" means the floor rate of interest announced by the State Bank of India for all its lending operations;

"Base Date" means the last date of the calendar month, which precedes the Bid Due Date by at least 28 (twenty-eight) days;

"Bid" means the documents in their entirety comprised in the bid submitted by the [selected bidder/ Joint venture] in response to the Request for Proposal in accordance with the provisions thereof;

"**Bid Security**" means the bid security provided by the Contractor to the Authority in accordance with the Request for Proposal, and which is to remain in force until substituted by the Performance Security;

"Change in Law" means the occurrence of any of the following after the Base Date:

(a) the enactment of any new Indian law;

(b) the repeal, modification or re-enactment of any existing Indian law;

(c) the commencement of any Indian law which has not come into effect until the Base Date; or

(d) a change in the interpretation or application of any Indian law by a judgement of a court of record which has become final, conclusive and binding, as compared to such interpretation or application by a court of record prior to the Base Date.

"Change of Scope" shall have the meaning set forth in Article 13;

"Change of Scope Notice" shall have the meaning set forth in Clause 13.2 (i);

"**Change of Scope Request**" shall have the meaning set forth in Clause 13.2 (ii);

"Change of Scope Order" shall have the meaning set forth in Clause 13.2 (iv);

"Completion Certificate" shall have the meaning set forth in Clause 12.2;

"Construction" shall have the meaning set forth in Clause 1.2 (f);

"Construction Period" means the period commencing from the Appointed Date and ending on the date of the Completion Certificate;

"**Construction Zone**" shall have the meaning set forth in Clause 8.3 (i);

"Contract Price" means the amount specified in Clause 19.1 (i);

"Contractor" shall have the meaning attributed thereto in the array of Parties hereinabove as set forth in the Recitals;

"Contractor Default" shall have the meaning set forth in Clause 23.1;

"Cure Period" means the period specified in this Agreement for curing any breach or default of any provision of this Agreement by the Party responsible for such breach or default and shall:

(a) commence from the date on which a notice is delivered by one Party to the other Party asking the latter to cure the breach or default specified in such notice;

(b) not relieve any Party from liability to pay Damages or compensation under the provisions of this Agreement; and

(c) not in any way be extended by any period of Suspension under this Agreement; provided that if the cure of any breach default by the Contractor requires any reasonable action by the Contractor that must be approved by the Authority or the Authority's Engineer hereunder, the applicable Cure Period shall be extended by the period taken by the Authority or the Authority's Engineer to accord their approval;

"Damages" shall have the meaning set forth in paragraph (w) of Clause 1.2;

"Defect" means any defect or deficiency in Construction of the Works or any part thereof, which does not conform with the Specifications and Standards, and in the case of Maintenance, means any Defect or deficiency which is specified in Schedule-E;

"Defects Liability Period" shall have the meaning set forth in Clause 17.1;

"Dispute" shall have the meaning set forth in Clause 26.1;

"Dispute Resolution Procedure" means the procedure for resolution of Disputes set forth in Article 26;

"Drawings" means all of the drawings, calculations and documents pertaining to the Project Road as set forth in Schedule-I, and shall include 'as built' drawings of the Project Road;

"Document" or "Documentation" means documentation in printed or written form, or in tapes, discs, drawings, computer programmes, writings, reports, photographs, films, cassettes, or expressed in any other written, electronic, audio or visual form;

"Emergency" means a condition or situation that is likely to endanger the safety or security of the individuals on or about the Project Road, including Users thereof, or which poses an immediate threat of material damage to any of the Project Assets;

"Encumbrances" means, in relation to the Project Road, any encumbrances such as mortgage, charge, pledge, lien, hypothecation, security interest, assignment, privilege or priority of any kind having the effect of security or other such obligations, and shall include any designation of loss to payees or beneficiaries or any similar arrangement under any insurance policy pertaining to the Project Road, where applicable herein but excluding utilities referred to in Clause 9.1;

"EPC" means engineering, procurement and construction;

"Final Payment Certificate" shall have the meaning set forth in Clause 19.15;

"**Final Payment Statement**" shall have the meaning set forth in Clause 19.13;

"Force Majeure" or "Force Majeure Event" shall have the meaning ascribed to it in Clause 21.1;

"GAD" or "General Arrangement Drawings" shall have the meaning set forth in Clause 3.1 (iii) (b);

"GOI" or "Government" means the Government of India;

"GOK" means the Government of Karnataka;

"Good Industry Practice" means the practices, methods, techniques, designs, standards, skills, diligence, efficiency, reliability and prudence which are generally and reasonably expected from a reasonably skilled and experienced contractor engaged in the same type of undertaking as envisaged under this Agreement and which would be expected to result in the performance of its obligations by the Contractor in accordance with this Agreement, Applicable Laws and Applicable Permits in reliable, safe, economical and efficient manner;

"Government Instrumentality" means any department, division or sub- division of the Government or the State Government and includes any commission, board, authority, agency or municipal and other local authority or statutory body including panchayat under the control of the Government or the State Government, as the case

may be, and having jurisdiction over all or any part of the Project Road or the performance of all or any of the services or obligations of the Contractor under or pursuant to this Agreement;

"**Handover Memorandum**" shall have the meaning set forth in Clause 8.2;

"IRC" means the Indian Roads Congress;

"Indemnified Party" means the Party entitled to the benefit of an indemnity pursuant to Article 25;

"Indemnifying Party" means the Party obligated to indemnify the other Party pursuant to Article 25;

"Indirect Political Event" shall have the meaning set forth in Clause 21.3;

"Insurance Cover" means the aggregate of the maximum sums insured under the insurance taken out by the Contractor pursuant to Article 20, and includes all insurances required to be taken out by the Contractor under Clauses 20.1 and 20.9 but not actually taken, and when used in the context of any act or event, it shall mean the aggregate of the maximum sums insured and payable or deemed to be insured and payable in relation to such act or event;

"Intellectual Property" means all patents, trademarks, service marks, logos, get-up, trade names, internet domain names, rights in designs, blue prints, programmes and manuals, drawings, copyright (including rights in computer software), database rights, semi-conductor, topography rights, utility models, rights in know-how and other intellectual property rights, in each case whether registered or unregistered and including applications for registration, and all rights or forms of protection having equivalent or similar effect anywhere in the world;

"**Interim Payment Certificate**" or "**IPC**" means the interim payment certificate issued by the Authority's Engineer for payment to the Contractor in respect of Contractor's claims for payment raised in accordance with the provisions of this Agreement;

"Joint Venture" means the group of entities which have come together for implementation of this Project;

"Lead Member" shall, in the case of a joint venture, mean the member of such joint venture who shall have the authority to bind the contractor and each member of the Joint venture; and shall be deemed to be the Contractor for the purposes of this Agreement; the Lead Member shall itself undertake and perform at least 51% (fifty one per cent) of the total length of the Project Road;

"**LOA**" or "**Letter of Acceptance**" means the letter of acceptance issued by the Authority as referred to in Recital (D);

"Maintenance" means the maintenance of the Project Road as set forth in Article 14 for the period specified therein;

"**Maintenance Inspection Report**" shall have the meaning set forth in Clause 15.2;

"Maintenance Manual" shall have the meaning ascribed to it in Clause 10.7;

"Maintenance Programme" shall have the meaning set forth in Clause 14.3;

"Maintenance Period" shall have the meaning set forth in Clause 14.1;

"Maintenance Requirements" shall have the meaning set forth in Clause 14.2;

"Major Bridge" means a bridge having a total length of more than 60 (sixty) meters between the inner faces of the dirt walls as specified in IRC:5;

"**Manual**" shall mean the Manual of Standards and Specifications for Project Roads;

"Material Adverse Effect" means a material adverse effect of any act or event on the ability of either Party to perform any of its obligations under and in accordance with the provisions of this Agreement and which act or event causes a material financial burden or loss to either Party;

"Materials" comprise of all the supplies used by the Contractor used in the Works or for the maintenance of the Project Road;

"**Monthly Maintenance Statement** shall have the meaning set forth in Clause 19.6;

"**MORTH**" means the Ministry of Road Transport and Roads or any substitute thereof dealing with Roads;

"**Non-Political Event**" shall have the meaning set forth in Clause 21.2;

"Parties" means the parties to this Agreement collectively and "Party" shall mean any of the parties to this Agreement individually;

"Performance Security" and **"Additional Performance Security"** shall have the meaning set forth in Clause 7.1;

"Plant" means the apparatus and machinery intended to form or forming part of the works of the Works;

"Political Event" shall have the meaning set forth in Clause 21.4;

"Programme" shall have the meaning set forth in Clause 10.1 (iii);

"Project" means the construction and maintenance of the Project Road in accordance with the provisions of this Agreement, and includes all works, services and equipment relating to or in respect of the Scope of the Project;

"Project Assets" means all physical and other assets relating to (a) tangible assets such as civil works and equipment including foundations, embankments, pavements,

road surface, interchanges, bridges, culverts, road over-bridges, drainage works, traffic signals, sign boards, kilometre-stones, [toll plaza(s)], electrical systems, communication systems, rest areas, relief centres, maintenance depots and administrative offices; and (b) Project Facilities situated on the Site;

"Project Completion Date" means the date on which the Completion Certificate is issued;

"Project Completion Schedule" means the progressive Project Milestones set forth in Schedule-J for completion of the Project Road on or before the Scheduled Completion Date;

"Project Facilities" means all the amenities and facilities situated on the Site, as described in Schedule-C;

"**Project Road**" means the Site comprising Construction of 3-Lane Bi-Directional Road Underpass on Bellary Road between Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU) Campus, Bengaluru on EPC Mode and all Project Assets, and its subsequent development and augmentation in accordance with this Agreement;

"Project Milestone" means the project milestone set forth in Schedule-J;

"Proof Consultant" shall have the meaning set forth in Clause 10.2;

"Quality Assurance Plan" or **"QAP"** shall have the meaning set forth in Clause 11.2**;**

"Re.", "Rs." or "Rupees" or "Indian Rupees" or "INR" means the lawful currency of the Republic of India;

"**Request for Proposals**" *or* "**RFP**" shall have the meaning set forth in Recital 'C';

"Retention Money" shall have the meaning set forth in Clause 7.5;

"Right of Way" means and refers to the total land required and acquired for the project, both in its width and length, together with all way leaves, easements, unrestricted access and other rights of way, howsoever described, necessary for construction and maintenance of the Project Road in accordance with this Agreement;

"**Safety Consultant**" shall have the meaning set forth in Clause 10.1;

"Scheduled Completion Date" shall be the date set forth in Clause 10.3;

"Scheduled Construction Period" means the period commencing from the Appointed Date and ending on Scheduled Completion Date;

"Scope of the Project" shall have the meaning set forth in Clause 2.1;

"Section" means a part of the Project Road;

"Site" shall have the meaning set forth in Clause 8.1;

"Specifications and Standards" means the specifications and standards relating to the quality, quantity, capacity and other requirements for the Project Road, as set forth in Schedule-D, and any modifications thereof, or additions thereto, as included in the design and engineering for the Project Road submitted by the Contractor to, and expressly approved by, the Authority;

"**Stage Payment Statement**" shall have the meaning set forth in Clause 19.4;

"**Structures**" means an elevated road or a flyover, as the case may be;

"Sub-contractor" means any person or persons to whom a part of the Works or the Maintenance has been subcontracted by the Contractor and the permitted legal successors in title to such person, but not an assignee to such person;

"Suspension" shall have the meaning set forth in Article 22;

"**Taking Over Certificate**" shall have the meaning set forth in Clause 14.10;

"Taxes" means any Indian taxes including GST, excise duties, customs duties, value added tax, sales tax, local taxes, cess and any impost or surcharge of like nature (whether Central, State or local) on the goods, Materials, equipment and services incorporated in and forming part of the Project Road charged, levied or imposed by any Government Instrumentality, but excluding any interest, penalties and other sums in relation thereto imposed on any account whatsoever. For the avoidance of doubt, Taxes shall not include taxes on corporate income;

"Termination" means the expiry or termination of this Agreement;

"Termination Notice" means the communication issued in accordance with this Agreement by one Party to the other Party terminating this Agreement;

"Termination Payment" means the amount payable by either Party to the other upon Termination in accordance with Article 23;

"Terms of Reference" or "TOR" shall have the meaning set forth in Clause 18.2;

"Tests" means the tests set forth in Schedule-K to determine the completion of Works in accordance with the provisions of this Agreement;

"Time Extension" shall have the meaning set forth in Clause 10.5;

"User" means a person who travels or intends to travel on the Project Road or any part thereof in/on any vehicle;

"**Valuation of Unpaid works**" shall have the meaning set forth in Clause 23.5;

"Works" means all works including survey and investigation, design, engineering, procurement, construction, Plant, Materials, maintenance, temporary works and

other things necessary to complete the Project Road in accordance with this Agreement; and

"WPI" means the wholesale price index for various commodities as published by the Ministry of Commerce and Industry, GOI and shall include any index which substitutes the WPI, and any reference to WPI shall, unless the context otherwise requires, be construed as a reference to the WPI published for the period ending with the preceding month.

1.2 Interpretation

(i) In this Agreement, unless the context otherwise requires,

(a) references to any legislation or any provision thereof shall include amendment or re-enactment or consolidation of such legislation or any provision thereof so far as such amendment or re-enactment or consolidation applies or is capable of applying to any transaction entered into hereunder;

(b) references to laws of India or Indian law or regulation having the force of law shall include the laws, acts, ordinances, rules, regulations, bye laws or notifications which have the force of law in the territory of India and as from time to time may be amended, modified, supplemented, extended or re-enacted;

(c) references to a "person" and words denoting a natural person shall be construed as a reference to any individual, firm, company, corporation, society, trust, government, state or agency of a state or any association or partnership (whether or not having separate legal personality) of two or more of the above and shall include successors and assigns;

(d) the table of contents, headings or sub-headings in this Agreement are for convenience of reference only and shall not be used in, and shall not affect, the construction or interpretation of this Agreement;

(e) the words "include" and "including" are to be construed without limitation and shall be deemed to be followed by "without limitation" or "but not limited to" whether or not they are followed by such phrases;

(f) references to "construction" or "building" include, unless the context otherwise requires, survey and investigation, design, developing, engineering, procurement, supply of plant, materials, equipment, labour, delivery, transportation, installation, processing, fabrication, testing, and commissioning of the Project Road, including maintenance during the Construction Period, removing of defects, if any, and other activities incidental to the construction and "construct" or "build" shall be construed accordingly;

(g) references to "development" include, unless the context otherwise requires, construction, renovation, refurbishing, augmentation, up- gradation and other activities incidental thereto during the Construction Period, and "develop" shall be construed accordingly;

(h) any reference to any period of time shall mean a reference to that according to Indian standard time;

(i) any reference to day shall mean a reference to a calendar day;

(j) references to a "business day" shall be construed as a reference to a day (other than a Sunday) on which banks in Bengaluru are generally open for business;

(k) any reference to month shall mean a reference to a calendar month as per the Gregorian calendar;

(l) references to any date, period or Project Milestone shall mean and include such date, period or Project Milestone as may be extended pursuant to this Agreement;

(m) any reference to any period commencing "from" a specified day or date and "till" or "until" a specified day or date shall include both such days or dates; provided that if the last day of any period computed under this Agreement is not a business day, then the period shall run until the end of the next business day;

(n) the words importing singular shall include plural and vice versa;

(o) references to any gender shall include the other and the neutral gender;

(p) "lakh" means a hundred thousand (100,000) and "crore" means ten million (10,000,000);

(q) "indebtedness" shall be construed so as to include any obligation (whether incurred as principal or surety) for the payment or repayment of money, whether present or future, actual or contingent;

(r) references to the "winding-up", "dissolution", "insolvency", or "reorganisation" of a company or corporation shall be construed so as to include any equivalent or analogous proceedings under the law of the jurisdiction in which such company or corporation is incorporated or any jurisdiction in which such company or corporation carries on business including the seeking of liquidation, winding-up, reorganisation, dissolution, arrangement, protection or relief of debtors;

(s) save and except as otherwise provided in this Agreement, any reference, at any time, to any agreement, deed, instrument, licence or document of any description shall be construed as reference to that agreement, deed, instrument, licence or other document as amended, varied, supplemented, modified or suspended at the time of such reference; provided that this Clause shall not operate so as to increase liabilities or obligations of the Authority hereunder or pursuant hereto in any manner whatsoever;

(t) any agreement, consent, approval, authorisation, notice, communication, information or report required under or pursuant to this Agreement from or by any Party or the Authority's Engineer shall be valid and effective only if it is in writing under the hand of a duly authorised representative of such Party or the Authority's Engineer, as the case may be, in this behalf and not otherwise;

(u) the Schedules and Recitals to this Agreement form an integral part of this Agreement and will be in full force and effect as though they were expressly set out in the body of this Agreement;

(v) references to Recitals, Articles, Clauses, Sub-clauses or Schedules in this Agreement shall, except where the context otherwise requires, mean references to Recitals, Articles, Clauses, Sub-clauses and Schedules of or to this Agreement, and references to a Paragraph shall, subject to any contrary indication, be construed as a reference to a Paragraph of this Agreement or of the Schedule in which such reference appears;

(w) the damages payable by either Party to the other of them, as set forth in this Agreement, whether on per diem basis or otherwise, are mutually agreed genuine pre-estimated loss and damage likely to be suffered and incurred by the Party entitled to receive the same and are not by way of penalty or liquidated damages (the "Damages"); and

(x) time shall be of the essence in the performance of the Parties' respective obligations. If any time period specified herein is extended for the reasons specified in the Agreement, such extended time shall also be of the essence.

(ii) Unless expressly provided otherwise in this Agreement, any Documentation required to be provided or furnished by the Contractor to the Authority shall be provided free of cost and in three copies, and if the Authority is required to return any such Documentation with its comments and/or approval, it shall be entitled to retain two copies thereof.

(iii) The rule of construction, if any, that a contract should be interpreted against the parties responsible for the drafting and preparation thereof, shall not apply.

(iv) Any word or expression used in this Agreement shall, unless otherwise defined or construed in this Agreement, bear its ordinary English meaning and, for these purposes, the General Clauses Act, 1897 shall not apply.

1.3 Measurements and arithmetic conventions

All measurements and calculations shall be in the metric system and calculations done to 2 (two) decimal places, with the third digit of 5 (five) or above being rounded up and below 5 (five) being rounded down.

1.4 Priority of agreements and errors/discrepancies

(i) This Agreement, and all other agreements and documents forming part of or referred to in this Agreement are to be taken as mutually explanatory and, unless otherwise expressly provided elsewhere in this Agreement, the priority of this Agreement and other documents and agreements forming part hereof or referred to herein shall, in the event of any conflict between them, be in the following order:

(a) this Agreement; and

(b) all other agreements and documents forming part hereof or referred to herein; i.e. this Agreement at (a) above shall prevail over the agreements and documents at (b).

(ii) Subject to the provisions of Clause 1.4 (i), in case of ambiguities or discrepancies within this Agreement, the following shall apply:

(a) between two or more Clauses of this Agreement, the provisions of a specific Clause relevant to the issue under consideration shall prevail over those in other Clauses;

(b) between the Clauses of this Agreement and the Schedules, the Clauses shall prevail and between Schedules and Annexes, the Schedules shall prevail;

(c) between any two Schedules, the Schedule relevant to the issue shall prevail;

(d) between the written description on the Drawings and the Specifications and Standards, the latter shall prevail;

(e) between the dimension scaled from the Drawing and its specific written dimension, the latter shall prevail; and

(f) between any value written in numerals and that in words, the latter shall prevail.

1.5 Joint and several liability

(i) If the Contractor has formed a Joint Venture of two or more persons for implementing the Project:

(a) these persons shall, without prejudice to the provisions of this Agreement or any other agreement, be deemed to be jointly and severally liable to the Authority for the performance of the Agreement; and

(b) the Contractor shall ensure that no change in the composition of the Joint Venture is effected without the prior consent of the Authority.

(ii) Without prejudice to the joint and several liability of all the members of the Joint Venture, the Lead Member shall represent all the members of the Joint Venture and shall always be liable and responsible for discharging the functions and obligations of the Contractor. The Contractor shall ensure that each member of the Joint Venture shall be bound by any decision, communication, notice, action or inaction of the Lead Member on any matter related to this Agreement and the Authority shall be entitled to rely upon any such action, decision or communication of the Lead Member. The Authority shall have the right to release payments solely to the Lead Member and shall not in any manner be responsible or be held liable for the inter se allocation of payments among members of the Joint venture.[6]

[6] This Clause 1.5 may be omitted if the Contractor is not a Joint venture. Even if the Contractor is a Joint venture, the Authority may, at its discretion, delete this provision.

Part II

Scope of Project

Article 2

Scope of the Project

2.1 Scope of the Project

Under this Agreement, the scope of the Project (the **"Scope of the Project"**) shall mean and include:

(a) construction of the Project Road on the Site set forth in Schedule- A and as specified in Schedule-B together with provision of Project Facilities as specified in Schedule-C, and in conformity with the Specifications and Standards set forth in Schedule-D;

(b) maintenance of the Project Road in accordance with the provisions of this Agreement and in conformity with the requirements set forth in Schedule-E; and

(c) performance and fulfilment of all other obligations of the Contractor in accordance with the provisions of this Agreement and matters incidental thereto or necessary for the performance of any or all of the obligations of the Contractor under this Agreement.

Article 3

Obligations of the Authority

3.1 Obligations of the Authority

(i) The Authority shall, at its own cost and expense, undertake, comply with and perform all its obligations set out in this Agreement or arising hereunder.

(ii) The Authority shall be responsible for the correctness of the Scope of the Project, Project Facilities, Specifications and Standards and the criteria for testing of the completed Works.

(iii) The Authority shall, upon submission of the Performance Security as per the RFP by the Contractor, shall provide to the Contractor:

(a) No less than 90% (ninety per cent) of the required Right of Way of the Construction Zone of total length of the Project Road within a period of 30 (thirty) days from the date of this Agreement, which shall be in contiguous stretches of length not less than 5 (five) kilometre.

(b) all environmental clearances as required under Clause 3.3.[8]

(iv) Delay in providing the Right of Way or approval of GAD by railway authorities, as the case may be, in accordance with the provisions of Clause 3.1 (iii) shall entitle the Contractor to Damages in a sum calculated in accordance with the provisions of Clause 8.3 of this Agreement and Time Extension in accordance with the provisions of Clause 10.5 of this Agreement. For the avoidance of doubt, the Parties agree that the Damages for delay in approval of GAD by the railway authorities for a particular road over-bridge/ under-bridge shall be deemed to be equal to the Damages payable under the provisions of Clause 8.3 for delay in providing Right of Way for a length of 2 (two) kilometre for each such road over-bridge/ under-bridge.

[7] Clause (b) may be omitted if the Project does not include a road over-bridge/under-bridge.

[8] Clause 3.1 (iii) (c) may be suitably modified in the event that all the environmental clearances for the Project Road have been received or are not required. It should be clearly stated that all the environmental clearances for the Project Road have been received; or such environmental clearances for the Project Road are not required.

(v) Notwithstanding anything to the contrary contained in this Agreement, the Parties expressly agree that the aggregate Damages payable under Clauses 3.1 (iv), 8.3 and 9.5 shall not exceed 1% (one per cent) of the Contract Price. For the avoidance of doubt, the Damages payable by the Authority under the aforesaid Clauses shall not be additive if they arise concurrently from more than one cause but relate to the same part of the Project Road.

Both the parties agree that payment of such Damages shall be full and final settlement of all claims of the Contractor, and such compensation shall be the sole remedy against delays of the Authority and both parties further agree that the payment of Damages shall be the final cure for the Contractor against delays of the Authority, without recourse to any other payments.

(vi) The Authority agrees to provide support to the Contractor and undertakes to observe, comply with and perform, subject to and in accordance with the provisions of this Agreement and the Applicable Laws, the following:

(a) upon written request from the Contractor, and subject to the Contractor complying with Applicable Laws, provide reasonable support to the Contractor in procuring Applicable Permits required from any Government Instrumentality for implementation of the Project;

(b) upon written request from the Contractor, provide reasonable assistance to the Contractor in obtaining access to all necessary infrastructure facilities and utilities, including water and electricity at rates and on terms no less favourable than those generally available to commercial customers receiving substantially equivalent services;

(c) procure that no barriers that would have a material adverse effect on the works are erected or placed on or about the Project Road by any Government Instrumentality or persons claiming through or under it, except for reasons of Emergency, national security, law and order or collection of inter-state taxes;

(d) not do or omit to do any act, deed or thing which may in any manner violate any provisions of this Agreement;

(e) support, cooperate with and facilitate the Contractor in the implementation of the Project in accordance with the provisions of this Agreement; and

(f) upon written request from the Contractor and subject to the provisions of Clause 4.3, provide reasonable assistance to the Contractor and any expatriate personnel of the Contractor or its Sub-contractors to obtain the applicable visas and the requisite work permits for the purposes of discharge by the Contractor or its Sub-contractors of their obligations under this Agreement and the agreements with the Sub-contractors.

3.2 Maintenance obligations prior to the Appointed Date

The Authority shall, prior to the Appointed Date, maintain the Project Road, at its own cost and expense, so that its traffic worthiness and safety are at no time materially inferior as compared to its condition 10 (ten) days prior to the last date for submission of the Bid, and in the event of any material deterioration or damage other than normal wear and tear, undertake repair thereof. For the avoidance of doubt, the Authority shall undertake only routine maintenance prior to the Appointed Date, and it shall undertake special repairs only in the event of excessive deterioration or damage caused due to unforeseen events such as floods or earthquakes.

3.3 Environmental Clearances

The Authority represents and warrants that the environmental clearances required for construction of the Project shall be procured by the Authority prior to the date of issue of LOA. For the avoidance of doubt, the present status of environmental clearances is specified in Schedule-A.[9]

3.4 Deemed Termination upon delay

Without prejudice to the provisions of Clauses 8.3, and subject to the provisions of Clause 7.3, the Parties expressly agree that in the event the Appointed Date does not occur, for any reason whatsoever, within 90 days of signing of the Agreement and submission of the full Performance Security by the Contractor, the Agreement shall be deemed to have been terminated. The Authority shall pay damages to the Contractor equivalent to 1% of the Contract Price (3% in case of standalone bridge projects). All other rights, privileges, claims and entitlements of the Contractor under or arising out of this Agreement shall be deemed to have been waived by, and to have ceased. The Contractor shall hand over all information in relation to the Road, including but not limited to any data, designs, drawings, structures, information, plans, etc. prepared by them for the Road, to the Authority.

[9] Clause 3.3 may be suitably modified in the event that all the environmental clearances for the Project Road have been received or are not required. It should be clearly stated that all the environmental clearances for the Project Road have been received; or such environmental clearances for the Project Road are not required.

Article 4

Obligations of the Contractor

4.1 Obligations of the Contractor

(i) Subject to and on the terms and conditions of this Agreement, the Contractor shall undertake the survey, investigation, design, engineering, procurement, construction, and maintenance of the Project Road and observe, fulfil, comply with and perform all its obligations set out in this Agreement or arising hereunder.

(ii) The Contractor shall comply with all Applicable Laws and Applicable Permits (including renewals as required) in the performance of its obligations under this Agreement.

(iii) Subject to the provisions of Clauses 4.1 (i) and 4.1 (ii), the Contractor shall discharge its obligations in accordance with Good Industry Practice and as a reasonable and prudent person.

(iv) The Contractor shall remedy any and all loss, defects, or damage to the Project Road from the Appointed Date until the end of the Construction Period at the Contractor's cost, save and except to the extent that any such loss, defect, or damage shall have arisen from any wilful default or neglect of the Authority.

(v) The Contractor shall remedy any and all loss, defect or damage to the Project Road during the Defects Liability Period at the Contractor's cost to the extent that such loss, defect or damage shall have arisen out of the reasons specified in Clause 17.3.

(vi) The Contractor shall remedy any and all loss or damage to the Project Road during the Maintenance Period at the Contractor's cost, including those stated in Clause 14.1 (ii), save and except to the extent that any such loss or damage shall have arisen on account of any wilful default or neglect of the Authority or on account of a Force Majeure Event.

(vii) The Contractor shall, at its own cost and expense, in addition to and not in derogation of its obligations elsewhere set out in this Agreement:

(a) make, or cause to be made, necessary applications to the relevant Government Instrumentalities with such particulars and details as may be required for obtaining Applicable Permits set forth in Schedule-F and obtain and keep in force and effect such Applicable Permits in conformity with the Applicable Laws;

(b) procure, as required, the appropriate proprietary rights, licences, agreements and permissions for Materials, methods, processes and systems used or incorporated into the Project Road;

(c) make reasonable efforts to maintain harmony and good industrial relations among the personnel employed byit or its Sub-contractors in connection with the performance of its obligations under this Agreement;

(d) ensure and procure that its Sub-contractors comply with all Applicable Permits and Applicable Laws in the performance by them of any of the Contractor's obligations under this Agreement;

(e) not do or omit to do any act, deed or thing which may in any manner violate any provisions of this Agreement;

(f) support, cooperate with and facilitate the Authority in the implementation and operation of the Project in accordance with the provisions of this Agreement;

(g) ensure that the Contractor and its Sub-contractors comply with the safety and welfare measures for labour in accordance with the Applicable Laws and Good Industry Practice;

(h) keep, on Site, a copy of this Agreement, publications named in this Agreement, the Drawings, Documents relating to the Project, and Change of Scope orders and other communications given under this Agreement. The Authority's Engineer and its authorised personnel shall have the right of access to all these documents at all reasonable times;

(i) cooperate with other contractors employed by the Authority and personnel of any public authority; and

(j) not interfere unnecessarily or improperly with the convenience of the public, or the access to and use and occupation of all roads and footpaths, irrespective of whether they are public or in the possession of the Authority or of others.

(viii) The Contractor shall undertake all necessary superintendence to plan, arrange, direct, manage, inspect and test the Works. The Contractor shall provide all necessary superintendence of the Works for the proper fulfilling of the Contractor's obligations under the Agreement. Such superintendence shall be given by competent person having adequate knowledge of the operations to be carried out (including the methods and techniques required, the hazards likely to be encountered and methods of preventing accidents) for the satisfactory and safe execution of the Works.

(ix) The Contractor shall obtain and maintain a project related bank account operational at site where all transactions related to the payment of work will be done. The Contractor shall submit a monthly account statement and a detailed report on utilization of funds transferred to this project related bank account to Authority's Engineer. Notwithstanding anything contrary to this agreement, the authority, in the interest and to ensure timely completion of the work, reserves the right to audit such bank accounts to ensure that there is no diversion of funds from this project specific account to any other project being implemented by the Contractor.

(x) The Contractor shall provide the documents of the Contractor specified in the Agreement, and all Contractors' personnel; Goods, consumables and other things and services, whether of a temporary or permanent nature, required in and for the execution, completion of Works and remedying defects.

(xi) The Contractor shall perform the Works in conformity with the Project requirements and other requirements and standards prescribed under or pursuant to the Agreement.

(xii) The Contractor shall carry out such work incidental and contingent to the original Scope of the Project to comply with Good Industry Practices.

(xiii) The Contractor shall maintain required staff and necessary Contractor's equipment and materials within the reach of the Site during the Defects Liability Period so that any defects arising are promptly attended.

4.2 Obligations relating to sub-contracts and any other agreements

(i) The Contractor, whether Joint Venture or sole, shall not sub-contract any Works in more than **49% (forty-nine per cent)** of the Contract Price and shall carry out Works directly under its own supervision and through its own personnel and equipment in **at least 51% (fifty one per cent)** of the Contract Price. Further, in case the Contractor is a Joint Venture, then the Lead Member shall carry out Works directly through its own resources (men, material and machines etc.) in **at least 51% (fifty-one per cent)** of total length of the Project Road. Provided, however, that in respect of the Works carried out directly by the Contractor, it may enter into contracts for the supply and installation of Materials, Plant, equipment, road furniture, safety devices and labour, as the case may be, for such Works. For the avoidance of doubt, the Parties agree that the Contractor may sub-divide the aforesaid length of **51% (fifty-one per cent)** in no more than 5 (five) sections of the Project Road. The Parties further agree that all obligations and liabilities under this Agreement for the entire Project Road shall at all times remain with the Contractor.

(ii) In the event any sub-contract for Works, or the aggregate of such sub-contracts with any Sub-contractor, exceeds 5% (five percent) of the Contract Price, the Contractor shall communicate the name and particulars, including the relevant experience of the Sub-contractor, to the Authority prior to entering into any such sub-contract. The Authority shall examine the particulars of the Sub- contractor from the national security and public interest perspective and may require the Contractor, no later than 15 (fifteen) business days from the date of receiving the communication from the Contractor, not to proceed with the sub-contract, and the Contractor shall comply therewith.

(iii) In the event any sub-contract referred to in Clause 4.2 (ii) relates to a Sub- contractor who has, over the preceding 3 (three) years, not undertaken at least one work of a similar nature with a contract value exceeding 40% (forty per cent) of the value of the sub-contract to be awarded hereunder, and received payments in respect thereof for an amount equal to at least such 40% (forty per cent), the Authority may, no later

than 15 (fifteen) business days from the date of receiving the communication from the Contractor, require the Contractor not to proceed with such sub-contract, and the Contractor shall comply therewith without delay or demur.

(iv) It is expressly agreed that the Contractor shall, at all times, be responsible and liable for all its obligations under this Agreement notwithstanding anything contained in the agreements with its Sub-contractors or any other agreement that may be entered into by the Contractor, and no default under any such agreement shall excuse the Contractor from its obligations or liability under this Agreement. However, in case of non-compliance of the Contractor towards his obligations for payments to the approved Sub-contractor(s), which is likely to affect the progress of works, the authority reserves the right to intervene and direct the Contractor to release such outstanding payments to approved Sub-contractor(s) out of the payments due for the completed Works in the interest of work.

4.3 Employment of foreign nationals

The Contractor acknowledges, agrees and undertakes that employment of foreign personnel by the Contractor and/or its Sub-contractors and their sub- contractors shall be subject to grant of requisite regulatory permits and approvals including employment/ residential visas and work permits, if any required, and the obligation to apply for and obtain the same shall always rest with the Contractor. Notwithstanding anything to the contrary contained in this Agreement, refusal of or inability to obtain any such permits and approvals by the Contractor or any of its Sub- contractors or their sub-contractors shall not constitute a Force Majeure Event, and shall not in any manner excuse the Contractor from the performance and discharge it of its obligations and liabilities under this Agreement, and the Contractor's liabilities hereunder shall remain unaffected by such failure, refusal or inability.

4.4 Contractor's personnel

(i) The Contractor shall ensure that the personnel engaged by it or by its Sub- contractors in the performance of its obligations under this Agreement are at all times appropriately and adequately qualified, skilled and experienced in their respective functions in conformity with Good Industry Practice. The Contractor will try to hire at least 10% (ten percent) trained workmen as per the National Skills Qualifications Framework. If necessary, the requisite workmen may be got trained by the Contractor at his cost through authorized training centres of the Directorate General of Training (DGT). The Contractor will organize training at project site/ sites for the trainees as and when required as per the training schedule finalized in consultation with the training centres. The trainees shall be paid stipend by the Contractor (subject to a maximum of Rs. 15,000/- per person) on the basis of minimum wages to compensate for loss of income during the training period.

(ii) The Authority's Engineer may, for reasons to be specified in writing, direct the Contractor to remove any member of the Contractor's or Sub-contractor's personnel. Provided that any such direction issued by the Authority's Engineer shall specify the reasons for the removal of such person.

(iii) The Contractor shall on receiving such a direction from the Authority's Engineer order for the removal of such person or persons with immediate effect. It shall be the duty of the Contractor to ensure that such persons are evicted from the Site within 10 (ten) days of any such direction being issued in pursuance of Clause 4.4 (ii). The Contractor shall further ensure that such persons have no further connection with the Works or Maintenance under this Agreement. The Contractor shall then appoint (or cause to be appointed) a replacement.

4.5 Advertisement on Project Road

The Project Road or any part thereof shall not be used in any manner to advertise any commercial product or services.

4.6 Contractor's care of the Works

The Contractor shall bear full risk in, and take full responsibility for, the care of the Works, and of the Materials, goods and equipment for incorporation therein, from the Appointed Date until the date of Completion Certificate, save and except to the extent that any such loss or damage shall have arisen from any wilful default or gross neglect of the Authority.

4.7 Electricity, water and other services

The Contractor shall be responsible for procuring of all utilities as may be required, including without limitation, adequate power, water and other services.

4.8 Unforeseeable difficulties

Except as otherwise stated in the Agreement:

(a) the Contractor accepts complete responsibility for having foreseen all difficulties and costs of successfully completing the Works;

(b) the Contract Price shall not be adjusted to take account of any unforeseen difficulties or costs; and

(c) the Scheduled Completion Date shall not be adjusted to take account of any unforeseen difficulties or costs.

4.9 Co-ordination of the Works

(i) The Contractor acknowledges that in addition to the Agreement, it is also aware of terms of the other Project contracts and other agreements the Authority has negotiated and entered into for performance of its obligations under the Agreement (copies of other contracts and other agreements are made available to the Contractor from time to time) and that the Contractor is fully aware of the consequences to the Authority which would or are likely to result from a breach by the Contractor of its obligations under the Agreement. In the event the actions of the Contractor result in the breach by the Authority of any or all of the other Project contracts and such breach imposes any liability on the Authority, the Contractor shall: (a) undertake all

steps as may be possible to mitigate or neutralize the liability that has arisen, and (b) indemnify the Authority against any such liability and compensate the Authority to that extent.

(ii) The Contractor shall be responsible for the co-ordination and proper provision of the Works, including co-ordination of other Contractors or Sub-contractors for the Project. The Contractor shall co-operate with the Authority in the co- ordination of the Works with the works under the other Project contracts. The Contractor shall provide all reasonable support for carrying out their work to:

(a) any other contractors employed by the Authority;

(b) the workmen of the Authority;

(c) the workmen of any Governmental Instrumentality who may be employed in the execution of work on or near the Site; and

(d) such other persons as is required in the opinion of the Authority for successful completion of the Project.

4.10 Environmental Measures

(i) The Contractor agrees to conduct its activities in connection with the Agreement in such a manner so as to comply with the environmental requirements which includes, *inter alia*, all the conditions required to be satisfied under the environmental clearances and applicable law, and assumes full responsibility for measures which are required to be taken to ensure such compliance.

4.11 Site Data

(i) The Contractor shall be deemed to have inspected and examined the Site and its surroundings and to have satisfied himself before entering into the Agreement in all material respects including but not limited to:

(a) the form and nature of the Site (including, inter-alia, the surface and sub-surface conditions and geo-technical factors);

(b) the hydrological and climatic conditions;

(c) the extent and nature of the works already completed and Materials necessary for the execution and completion of the Works and the remedying of any defects that includes already executed part also.

(d) the suitability and the adequacy of the Site for the execution of the Works;

(e) the means of access to the Site and the accommodation the Contractor may require;

(f) arranging permits as required as per [.] of the Agreement.

(g) the requirements of operation and maintenance; and

(h) all other factors and circumstances affecting the Contractor's rights and obligations under the Agreement, the Contract Price and Time for Completion.

4.12 Sufficiency of Contract Price

The Contractor shall have satisfied itself as to the correctness and sufficiency of the Contract Price. The Contract Price shall cover all its obligations under the Agreement, in addition to all risks the Contractor has agreed to undertake under the Agreement, including those associated with the performance of its obligations under the Agreement and all things necessary for the provision of the Works in a manner satisfactory to the Authority and in accordance with this Agreement.

4.13 Clearance of the Site

During the provision of the Works, and as a pre-condition to the issue of the Taking-Over Certificate, the Contractor shall clear away and remove from the Site, all Contractor's equipment, surplus material, wreckage, rubbish and temporary Works, and shall keep the Site free from all unnecessary obstructions, and shall not store or dispose of any Contractor's equipment or surplus materials on the Site. The Contractor shall promptly clear away and remove from the Site any wreckage, rubbish or temporary Works no longer required and leave the Site and the Works in a clean and safe condition to the sole satisfaction of the Authority

4.14 Obligations relating to Local Content

The Contractor [Class I Local Supplier/Class II Local Supplier/Non Local Supplier] undertakes to ensure minimum Local Content in the Project Road of at least [50%/20%] duly complying with the provisions of Department for Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, Government of India Order No. P-45021/2/2017-PP (BE-II) dated September 16, 2020, as amended or modified till Bid Due Date and the provisions under Rule 144(xi) of GFR, 2017.

Article 5

Representations and Warranties

5.1 Representations and warranties of the Contractor

(i) The Contractor represents and warrants to the Authority that:

(a) it is duly organised and validly existing under the laws of India, and has full power and authority to execute and perform its obligations under this Agreement and to carry out the transactions contemplated hereby;

(b) it has taken all necessary corporate and/or other actions under Applicable Laws to authorise the execution and delivery of this Agreement and to validly exercise its rights and perform its obligations under this Agreement;

(c) this Agreement constitutes its legal, valid and binding obligation, enforceable against it in accordance with the terms hereof, and its obligations under this Agreement will be legally valid, binding and enforceable against it in accordance with the terms hereof;

(d) it is subject to the laws of India, and hereby expressly and irrevocably waives any immunity in any jurisdiction in respect of this Agreement or matters arising thereunder including any obligation, liability or responsibility hereunder;

(e) the information furnished in the Bid, Request for Qualification and Request for Proposals or otherwise and as updated on or before the date of this Agreement is true and accurate in all respects as on the date of this Agreement;

(f) the execution, delivery and performance of this Agreement will not conflict with, or result in the breach of, or constitute a default under, or accelerate performance required by any of the terms of its memorandum and articles of association or any Applicable Laws or any covenant, contract, agreement, arrangement, understanding, decree or order to which it is a party or by which it or any of its properties or assets is bound or affected;

(g) there are no actions, suits, proceedings, or investigations pending or, to its knowledge, threatened against it at law or in equity before any court or before any other judicial, quasi-judicial or other authority, the outcome of which may result in the breach of this Agreement or which individually or in the aggregate may result in any material impairment of its ability to perform any of its obligations under this Agreement;

(h) it has no knowledge of any violation or default with respect to any order, writ, injunction or decree of any court or any legally binding order of any Government Instrumentality which may result in any material adverse effect on its ability to perform its obligations under this Agreement and no fact or

circumstance exists which may give rise to such proceedings that would adversely affect the performance of its obligations under this Agreement;

(i) it has complied with Applicable Laws in all material respects and has not been subject to any fines, penalties, injunctive relief or any other civil or criminal liabilities which in the aggregate have or may have a material adverse effect on its ability to perform its obligations under this Agreement;

(j) no representation or warranty by it contained herein or in any other document furnished by it to the Authority or to any Government Instrumentality in relation to Applicable Permits contains or will contain any untrue or misleading statement of material fact or omits or will omit to state a material fact necessary to make such representation or warranty not misleading;

(k) no sums, in cash or kind, have been paid or will be paid, by it or on its behalf, to any person by way of fees, commission or otherwise for securing the contract or entering into this Agreement or for influencing or attempting to influence any officer or employee of the Authority in connection therewith;

(l) nothing contained in this Agreement shall create any contractual relationship or obligation between the Authority and any Sub- contractors, designers, consultants or agents of the Contractor;

(m) it is adequately financed has the requisite knowledge, expertise, technical know-how, experience, resources, infrastructure, licenses, patents, copy rights, for designing, supplying/ procuring the goods and materials, and for providing the installation and construction services required for completing the construction of the Project Facilities; and

(ii) it represents the Authority that:

(a) it owns or has the right to use all **"Intellectual Property"** necessary to perform the contractual obligations and to carry on the Works without conflict with the right of others;

(b) All intellectual property rights necessary to perform the contractual obligations and to carry on the Works are in full force and effect and are vested in, and beneficially owned by the Contractor, and are free from encumbrances.

(c) None of the intellectual property rights is being used, claimed, or posed or attacked by any other person, nor does the use of such intellectual property rights or any part of them infringe the intellectual property rights owned or enjoyed by any third party.

(d) None of the intellectual property rights owned or used by the Contractor is the subject of any claim, opposition, attack, assertion or other arrangement of whatsoever nature which does or may impinge upon their use, validity, enforceability or ownership by the Parties, and there are no grounds or other circumstances which may give rise to the same.

(e) No licenses or registered user or other rights have been granted or agreed to be granted to any third party in respect of such intellectual property rights.

(f) No act has been done or has been omitted to be done to entitle any authority or person to cancel, forfeit or modify any intellectual property rights.

(g) The Contractor shall notify the Authority of any adverse use of the intellectual property rights or confusingly or deceptively similar to the intellectual property rights.

(h) The Contractor shall recognize the Authority's ownership and title to the intellectual property rights and shall not at any time, either directly or indirectly, put to issue the validity or ownership of the intellectual property rights and it will not do any act or thing, either directly or indirectly, which in anyway impairs the validity and ownership of the intellectual property rights.

(i) The Contractor shall, promptly execute, acknowledge and deliver all documents which are requested by Authority to record with appropriate governmental agencies and authorities the fact that the Authority has the right to the use of the said intellectual property rights.

(j) The Contractor shall not, for any reason, object to, or interfere in any way with the ownership, registration or use of the intellectual property rights by the Authority (or its licensee or assigns) for any purpose whatsoever.

(iii) The Contractor is fully aware that the Agreement is inter linked with the other Project contracts and the non-performance or deficient performance or default by the Contractor and/or any of the Contractor's personnel or Subcontractors under one among the said contracts will have bearing on the other contracts and the evaluation of the Contractor's performance under the Agreement and the Project itself.

(iv) If at any time during the Defects Liability Period any item of the Works or Project Facilities or any part thereof, do not conform to the Authority requirements and Specifications and Standards, on being so notified by the Authority, the Contractor shall promptly rectify/remedy such nonconformity to the satisfaction of the Authority solely at the Contractor's expense; failing which the Authority may reject or revoke Taking-Over Certificate, and the Authority may proceed to correct the Contractor's nonconforming Work by the most expeditious means available, the costs of which shall be to the Contractor's account; or the Authority may retain the non-conforming Work and an equitable adjustment reducing the total Contract Price to reflect the diminished value of such non-conforming Work will be made by written amendment.

(v) In addition to the other warranties, the Contractor represents and warrants as follows:

(a) The Contractor has (or, if the technology does not currently exist, will have granted at the time of passing to The Employer) in and to the technology used in the equipment, materials, goods, Works, Contractor's documents, Drawings and Manuals ("**Technology"**) -

i. all right, title and interest free of any lien, claim or restriction; and

ii. right to grant to the Authority the right to use the Technology for the purpose of this contract, free of any lien, claim or restriction and on the terms of license as required.

(b) The Contractor has granted (or, if the technology does not currently exist, will grant at the time of passing to the Authority the property and title in and to the equipment, materials, goods, Works, spares, Contractor's documents, Drawings and Manuals in which it is used) to the Authority the right to use the Technology, free of any lien, claim or restriction.

(vi) In addition to the other Warranties, the Contractor represents and warrants as follows:

(a) No Technology contains any worm (i.e., a program that travels from one computer to another computer but does not attach itself to the operating system of the computer it enters), virus (i.e., a program that travels from one computer to another computer that attaches itself to the operating system it enters) or self-destruct capability.

(b) The Technology will not abnormally end or provide invalid or incorrect results as a result of date-dependent data.

(c) The Technology can accurately recognize, manage, accommodate, and manipulate date-dependent data, including single and multi-century formulas and leap years.

(vii) No criminal proceedings instituted against any of the employees or Directors of the Contractor.

(viii) Till date the services of the Contractor has not been terminated by any person for any breach or non-performance or negligence by the Contractor.

5.2 Representations and warranties of the Authority

The Authority represents and warrants to the Contractor that:

(a) it has full power and authority to execute, deliver and perform its obligations under this Agreement and to carry out the transactions contemplated herein and that it has taken all actions necessary to execute this Agreement, exercise its rights and perform its obligations, under this Agreement;

(b) it has taken all necessary actions under the Applicable Laws to authorise the execution, delivery and performance of this Agreement;

(c) it has the financial standing and capacity to perform its obligations under this Agreement;

(d) this Agreement constitutes a legal, valid and binding obligation enforceable against it in accordance with the terms hereof;

(e) it has no knowledge of any violation or default with respect to any order, writ, injunction or any decree of any court or any legally binding order of any

Government Instrumentality which may result in any material adverse effect on the Authority's ability to perform its obligations under this Agreement;

(f) it has complied with Applicable Laws in all material respects;

(g) it has good and valid right to the Site and has the power and authority to grant the Right of Way in respect thereof to the Contractor; and

(h) it has procured Right of Way and environment clearances such that the Contractor can commence construction forthwith on 90% (ninety per cent) of the total length of the Project Road.

5.3 Disclosure

In the event that any occurrence or circumstance comes to the attention of either Party that renders any of its aforesaid representations or warranties untrue or incorrect, such Party shall immediately notify the other Party of the same. Such notification shall not have the effect of remedying any breach of the representation or warranty that has been found to be untrue or incorrect nor shall it adversely affect or waive any obligation of either Party under this Agreement.

Article 6

Disclaimer

6.1 Disclaimer

(i) The Contractor acknowledges that prior to the execution of this Agreement, the Contractor has, after a complete and careful examination, made an independent evaluation of the Request for Proposal, Scope of the Project, Specifications and Standards of design, construction and maintenance, Site, local conditions, physical qualities of ground, subsoil and geology, traffic volumes, suitability and availability of access routes to the Site and all information provided by the Authority or obtained, procured or gathered otherwise, and has determined to its satisfaction the accuracy or otherwise thereof and the nature and extent of difficulties, risks and hazards as are likely to arise or may be faced by it in the course of performance of its obligations hereunder. Save as provided in Clause 3.1 and Clause 5.2, the Authority makes no representation whatsoever, express, implicit or otherwise, regarding the accuracy, adequacy, correctness, reliability and/or completeness of any assessment, assumptions, statement or information provided by it and the Contractor confirms that it shall have no claim whatsoever against the Authority in this regard.

(ii) The Contractor acknowledges and hereby accepts to have satisfied itself as to the correctness and sufficiency of the Contract Price.

(iii) The Contractor acknowledges and hereby accepts the risk of inadequacy, mistake or error in or relating to any of the matters set forth in Clause 6.1 (i) above and hereby acknowledges and agrees that the Authority shall not be liable for the same in any manner whatsoever to the Contractor, or any person claiming through or under any of them, and shall not lead to any adjustment of Contract Price or Scheduled Completion Date.

(iv) The Parties agree that any mistake or error in or relating to any of the matters set forth in Clause 6.1 (i) above shall not vitiate this Agreement or render it voidable.

(v) In the event that either Party becomes aware of any mistake or error relating to any of the matters set forth in Clause 6.1 (i) above, that Party shall immediately notify the other Party, specifying the mistake or error.

(vi) Except as otherwise provided in this Agreement, all risks relating to the Project shall be borne by the Contractor; and the Authority shall not be liable in any manner for such risks or the consequences thereof.

Part III

Construction and Maintenance

Article 7

Performance Security

7.1 Performance Security

(A) Within 30 (thirty) days of receipt of Letter of Acceptance, the selected Bidder shall furnish to the Authority an irrevocable and unconditional guarantee from a Bank in the form set forth in Appendix-VII (the "Performance Security") for an amount equal to 3% (three percent) of its Bid Price. In case of bids mentioned below, the Selected Bidder, along with the Performance Security, shall also furnish to the Authority an irrevocable and unconditional guarantee from a Bank in the same given at Appendix-VII towards an Additional Performance Security (the "Additional Performance Security") for an amount calculated as under:

(i) If the Bid price offered by the selected bidder is lower than 20% of the estimated project cost/cost put to tender, the additional performance security shall be calculated @20% of the difference in the (i) Estimated Project Cost (as mentioned in RFP)- 20% of the Estimated Project Cost and (ii) the Bid Price offered by the selected Bidder.

(ii) Maximum limit of additional performance security shall be limited to 3% of the Bid Price offered by the selected Bidder.

(iii) The additional performance security shall be limited to 3% of the Bid Price offered by the selected bidder.

(iv) Additional performance security shall be taken only after approval of the ……. Bangalore Development Authority (BDA), mentioning specific reasons justifying the requirement of additional performance along with track record of the bidder.

(B) The Performance Security shall be valid until 60(sixty) days after the Defects Liability Period. The Additional Performance Security shall be valid until 28 (twenty-eight) days after Project Completion Date.

(i) The Selected Bidder has the option to provide 50% of the Performance Security and 50% of the Additional Performance Security, if any, within 30 (thirty) days of receipt of Letter of Acceptance, in any case before signing of the Contract Agreement and the remaining Performance Security and Additional Performance Security, if any, shall be submitted within 30 days of signing of this agreement.

(ii) In the event the Selected Bidder fails to provide the remaining Performance Security and Additional Performance Security, if any, as prescribed herein, it may seek extension of time for a further period upto 60 days by paying the Damages upfront along with the request letter seeking the extension. The Damages shall be the sum calculated at the rate of 0.01% (zero point zero one per cent) of the Bid Price offered by the Selected Bidder for each day until the Performance Security and Additional Performance Security, if any, is provided in full as prescribed herein. The damages at full rate as given above shall be applicable even if a part of the Performance Security and the Additional Performance Security is provided.

(iii) For avoidance of any doubt, in case of failure of submission of Performance Security

and Additional Performance Security, if any, within the additional 60 days' time period, the award shall be deemed to be cancelled/ withdrawn, and the Bid Security shall be encashed and the proceeds thereof appropriated by the Authority. Thereupon all rights, privileges, claims and entitlements of the Contractor under or arising out of the Award shall be deemed to have been waived by, and to have ceased with the concurrence of the Contractor, and the Award shall be deemed to have been withdrawn by the Authority

7.2 Extension of Performance Security and Additional Performance Security

The Contractor may initially provide the Performance Security for a period of 2 (two) years; provided that it shall procure the extension of the validity of the Performance Security, as necessary, at least 2 (two) months prior to the date of expiry thereof. Upon the Contractor providing an extended Performance Security, the previous Performance Security shall be deemed to be released and the Authority shall return the same to the Contractor within a period of 7 (seven) business days from the date of submission of the extended Performance Security.

7.3 Appropriation of Performance Security

(i) Upon occurrence of a Contractor's Default, the Authority shall, without prejudice to its other rights and remedies hereunder or in law, be entitled to encash and appropriate the relevant amounts from the Performance Security as Damages for such Contractor's Default.

(ii) Upon such encashment and appropriation from the Performance Security, the Contractor shall, within 30 (thirty) days thereof, replenish, in case of partial appropriation, to its original level the Performance Security, and in case of appropriation of the entire Performance Security provide a fresh Performance Security, as the case may be, and the Contractor shall, within the time so granted, replenish or furnish fresh Performance Security as aforesaid failing which the Authority shall be entitled to terminate the Agreement in accordance with Article 23. Upon replenishment or furnishing of a fresh Performance Security, as the case may be, as aforesaid, the Contractor shall be entitled to an additional Cure Period of 30 (thirty) days for remedying the Contractor's Default, and in the event of the Contractor not curing its default within such Cure Period, the Authority shall be entitled to encash and appropriate such Performance Security as Damages, and to terminate this Agreement in accordance with Article 23.

7.4 Release of Performance Security

(i) The Authority shall return the Performance Security to the Contractor within 60 (sixty) days of the expiry of the Maintenance Period or the Defects Liability Period, whichever is later, under this Agreement. Notwithstanding the aforesaid, the Parties agree that the Authority shall not be obliged to release the Performance Security until all Defects identified during the Defects Liability Period have been rectified.

(ii) The Authority shall return the Additional Performance Security to the Contractor within 28 (twenty-eight) days from the date of issue of Completion Certificate under Article 12 of this Agreement.

(iii) The Authority shall be liable to pay interest @ 9% (nine per cent) per annum for any delay in the return of Performance Security and Additional Performance Security, if any, beyond the period prescribed above for the period of delay.

7.5 Retention Money[10]

(i) From every payment for Works due to the Contractor in accordance with the provisions of Clause 19.5, the Authority shall deduct 6% (six per cent) thereof as guarantee money for performance of the obligations of the Contractor during the Construction Period (the "**Retention Money**") subject to the condition that the maximum amount of Retention Money shall not exceed 5% (five per cent) of the Contract Price.

(ii) Upon occurrence of a Contractor's Default, the Authority shall, without prejudice to its other rights and remedies hereunder or in law, be entitled to appropriate the relevant amounts from the Retention Money as Damages for such Contractor's Default.

(iii) Within 15 (fifteen) days of the date of issue of the Completion Certificate, the Authority shall refund the balance of Retention Money remaining with the Authority after adjusting the amounts appropriated under the provisions of Clause 7.5 (ii).

(iv) The Parties agree that in the event of Termination of this Agreement, the Retention Money specified in this Clause 7.5 shall be treated as if they are Performance Security and shall be reckoned as such for the purposes of Termination Payment under Clause 23.6.

[10] The Authority may, in its discretion, omit Clause 7.5 and in lieu thereof increase the Performance Security under Clause 7.1 from 7.5% (seven point five per cent) to 10% (ten per cent).

Article 8

Right of Way

8.1 The Site

The site of the Project Road (the "**Site**") shall comprise the site described in Schedule-A in respect of which the Right of Way shall be provided by the Authority to the Contractor. The Authority shall be responsible for:

(a) acquiring and providing Right of Way on the Site in accordance with the alignment finalised by the Authority, free from all encroachments and encumbrances, and free access thereto for the execution of this Agreement; and

(b) obtaining licences and permits for environment clearance for the Project Road.

8.2 Procurement of the Site

(i) The Authority Representative, the Contractor and Authority's Engineer shall, within 10 (ten) days of the date of this Agreement, inspect the Site and prepare a detailed memorandum containing an inventory of the Site including the vacant and unencumbered land, buildings, structures, road works, trees and any other immovable property on or attached to the Site (hereinafter referred to as the "**Handover Memorandum**"). Subject to the provisions of Clause 8.2 (iii), the Handover Memorandum shall have appended thereto an appendix (the "**Appendix**") specifying in reasonable detail those parts of the Site to which vacant access and Right of Way has not been given to the Contractor along with details of hindrances in the Construction Zone. For sake of clarity the Handover Memorandum shall clearly specify the parts of Site where work can be executed. Signing of the Handover Memorandum, in three counterparts (each of which shall constitute an original), by the authorized representatives of the Authority, Contractor and Authority's Engineer shall be deemed to constitute a valid evidence of giving the Right of Way to the Contractor for discharging its obligations under and in accordance with the provisions of this Agreement and for no other purpose whatsoever.

(ii) Whenever the Authority is ready to hand over any part or parts of the Site included in the Appendix, it shall inform the Contractor, by notice, of the proposed date and time of such hand over. The Authority's Representative and the Contractor shall, on the date so notified, inspect the specified parts of the Site, and prepare a memorandum containing an inventory of the vacant and unencumbered land, buildings, structures, road works, trees and any other immovable property on or attached to the Site so handed over. The signing of the memorandum, in three (3) counterparts (each of which shall constitute an original), by the authorised representatives of the Parties shall be deemed to constitute a valid evidence of giving the relevant Right of Way to the Contractor.

If the contractor fails to join for site inspection or disputes the parts of the site available for work, the Authority's Engineer shall decide the parts of the site where work can be executed and notify both the parties within 3 days of the proposed date of inspection. The parties agree that such notification of the Authority's Engineer as mentioned hereinabove shall be final and binding on the parties.

(iii) The Authority shall provide the Right of Way to the Contractor in respect of all land included in the Appendix by the date specified in Schedule-A for those parts of the Site referred to therein, and in the event of delay for any reason other than Force Majeure or breach of this Agreement by the Contractor, it shall pay to the Contractor, Damages in a sum calculated in accordance with Clause 8.3. The Contractor agrees that it shall not be entitled to claim any other damages on account of any such delay by the Authority.

(iv) Notwithstanding anything to the contrary contained in this Clause 8.2, the Authority shall specify the parts of the Site, if any, for which Right of Way shall be provided to the Contractor on the dates specified in Schedule-A. Such parts shall also be included in the Appendix prepared in pursuance of Clause 8.2 (i).

(v) The Authority further acknowledges and agrees that prior to the Appointed Date, it shall have procured issuance of the statutory notification under Applicable Laws for vesting of all the land comprising the Project in the Authority and has taken possession of area for Construction Zone for at least 90% (ninety per cent) of the total length of the Project Road. The Parties also acknowledge and agree that the conditions specified in this Clause 8.2 (iii) shall not be modified or waived by either Party.

(vi) For the avoidance of doubt, the Parties expressly agree that the Appendix shall in no event contain sections of the Project Road the cumulative length of which exceeds 10% (ten percent) of the total length of the Project Road.

(vii) Pursuant to signing of Handover Memorandum under clause 8.2 (i), Contractor shall submit to the Authority's Engineer, a monthly land possession report till expiry of 180 (one hundred and eighty) days from Appointed Date, in respect of those parts of the site to which vacant access and right of way was not given to the contractor and included in Appendix to the memorandum signed under clause 8.2 (i), duly specifying the part of the site, if any, for which the right of way is yet to be handed over.

8.3 Damages for delay in handing over the Site

(i) In the event the Right of Way to any part of the Site is not provided by the Authority on or before the date(s) specified in Clause 8.2 for any reason other than Force Majeure or breach of this Agreement by the Contractor, the Authority shall pay Damages to the Contractor a sum calculated in accordance with the following formula for and in respect of those parts of the Site to which the Right of Way has not been provided:

$$\text{Amount of Damages in Rs. per day per metre} = 0.05 \times C \times {}^{1}/_{L} \times {}^{1}/_{N}$$

Where,

C = the Contract Price;

L = length of the Project Road in metres; and

N = Completion period in days (Appointed Date to Scheduled Completion Date)

In the event that any Damages are due and payable to the Contractor under the provisions of this Clause 8.3 (i) for delay in providing the Right of Way, the Contractor shall, subject to the provisions of Clause 10.5, be entitled to Time Extension equal to the period for which the Damages have become due and payable under this Clause 8.3 (i), save and except that:

(a) if any delays involve time overlaps, the overlaps shall not be additive; and

(b) such Time Extension shall be restricted only to the Works which are affected by the delay in providing the Right of Way.

For the avoidance of doubt, the Parties expressly agree that the Damages specified hereunder and the Time Extension specified in Clause 10.5 shall be restricted only to failure of the Authority to provide the Right of Way for and in respect of the "Construction Zone" which shall comprise the following components:

- Main carriageway
- Median (for 4 lane carriageway or more)
- Paved and earthen shoulders
- Area for Structures including ROBs/RUBs.
- Safety measures including Roadside Drains and Furniture.
- A parallel working space for accommodating slopes/retaining structures etc.

(ii) Notwithstanding anything to the contrary contained in this Agreement, the Contractor expressly agrees that Works on all parts of the Site for which Right of Way of Construction Zone is granted on the Appointed Date, or with respect to the parts of the Site provided in Schedule-A, no later than the date(s) specified therein, as the case may be, shall be completed before the Scheduled Completion Date and shall not qualify for any Time Extension under the provisions of Clause 8.3 (iii).

(iii) (a) Notwithstanding anything to the contrary contained in this Agreement, unless covered under the deemed de-scoping in terms of sub-clause 8.3 (iii) (b), the Authority may at any time withdraw any Works forming part of this Agreement, subject to such Works not exceeding an aggregate value, such value to be determined in accordance with Schedule-H, equal to 10 (ten) percent of the Contract Price.

(b) Provided that if any Works cannot be undertaken within the municipal limits of a town or within any area falling in a reserved forest or wildlife sanctuary or the stretches where vacant access and Right of Way could not be handed over, as the case may be, because the requisite clearances or approvals or affected land parcels for commencing construction of Works therein have not been given within 180 (one hundred and eighty) days of the Appointed date, the affected Works shall be deemed to be withdrawn under the provisions of this Clause 8.3.3. Such Works shall not be computed for the purposes of the aforesaid ceiling of 10% (ten per cent) hereunder.

(c) Provided further that in case such stretches (as mentioned in Sub-Clause (b) above) can be handed over to the Contractor before the expiry of the original Scheduled Construction Period of the Project Road, and the Contractor agrees to take up the work, the same may be allowed to be executed by him with corresponding Extension of Time, subject to the condition that the Contractor shall not be entitled to raise any claims on account of prolongation costs in this behalf.

(iv) In the event of withdrawal of Works under Clause 8.3 (iii) (a), the Contract Price shall be reduced by an amount equal to the percent of the value of the works withdrawn as mentioned in the Table below and the Contractor shall not be entitled to any other compensation or Damages for the withdrawal of Works

Value of the Work withdrawn	**Percentage of value of works to be reduced from Contract Price**
Upto Rs. 100 Crore	90%
More than Rs. 100 Crore	Rs. 90 Crore plus 95% of the amount greater than Rs. 100 Crore

Provided that if any Works are withdrawn after commencement of the Construction of such works, the Authority shall pay to the Contractor 110% (one hundred and ten per cent) of the fair value of the work done, as assessed by the Authority' Engineer.

The parties expressly agree that the value of the Works withdrawn shall be determined from the details available in Schedule-H. In the event that it is impossible to determine the value from Schedule-H, then the value shall be determined in accordance with the provisions of Clause 13.2 (iii).

8.4 Site to be free from Encumbrances

Subject to the provisions of Clause 8.2, the Site shall be made available by the Authority to the Contractor pursuant hereto free from all Encumbrances and occupations and without the Contractor being required to make any payment to the Authority because of any costs, compensation, expenses and charges for the acquisition and use of such Site for the duration of the Project Completion Schedule. For the avoidance of doubt, it is agreed that the existing rights of way, easements, privileges, liberties and appurtenances to the Site shall not be deemed to be Encumbrances. It is further agreed that, unless otherwise specified in this Agreement, the Contractor accepts and

undertakes to bear any and all risks arising out of the inadequacy or physical condition of the Site.

8.5 Protection of Site from encroachments

On and after signing the memorandum and/or subsequent memorandum referred to in Clause 8.2, and until the issue of the Completion Certificate, the Contractor shall maintain a round-the-clock vigil over the Site and shall ensure and procure that no encroachment takes place thereon. During the Construction Period, the Contractor shall protect the Site from any and all occupations, encroachments or Encumbrances, and shall not place or create nor permit any Sub-contractor or other person claiming through or under the Agreement to place or create any Encumbrance or security threat over all or any part of the Site or the Project Assets, or on any rights of the Contractor therein or under this Agreement, save and except as otherwise expressly set forth in this Agreement. In the event of any encroachment or occupation on any part of the Site, the Contractor shall report such encroachment or occupation forthwith to the Authority and undertake its removal at its own cost and expenses.

8.6 Special/ temporary Right of Way

The Contractor shall bear all costs and charges for any special or temporary right of way required by it in connection with access to the Site. The Contractor shall obtain at its cost such facilities on or outside the Site as may be required by it for the purposes of the Project Road and the performance of its obligations under this Agreement.

8.7 Access to the Authority and the Authority's Engineer

(i) The Right of Way given to the Contractor hereunder shall always be subject to the right of access of the Authority and the Authority's Engineer and their employees and agents for inspection, viewing and exercise of their rights and performance of their obligations under this Agreement.

(ii) The Contractor shall ensure, subject to all relevant safety procedures, that the Authority has un-restricted access to the Site during any emergency situation, as decided by the Authority's Engineer.

8.8 Geological and archaeological finds

It is expressly agreed that mining, geological or archaeological rights do not form part of this Agreement with the Contractor for the Works, and the Contractor hereby acknowledges that it shall not have any mining rights or interest in the underlying minerals, fossils, antiquities, structures or other remnants or things either of particular geological or archaeological interest and that such rights, interest and property on or under the Site shall vest in and belong to the Authority or the concerned Government Instrumentality. The Contractor shall take all reasonable precautions to prevent its workmen or any other person from removing or damaging such interest or property and shall inform the Authority forthwith of the discovery thereof and comply with such instructions as the concerned Government Instrumentality may reasonably give for the removal of such property. For the avoidance of doubt, it is agreed that any reasonable

expenses incurred by the Contractor hereunder shall be reimbursed by the Authority. It is also agreed that the Authority shall procure that the instructions hereunder are issued by the concerned Government Instrumentality within a reasonable period.

Article 9

Utilities and Trees

9.1 Existing utilities and roads

Notwithstanding anything to the contrary contained herein, the Contractor shall ensure that the respective entities owning the existing roads, right of way or utilities on, under or above the Site are enabled by it to keep such utilities in continuous satisfactory use, if necessary, by providing suitable temporary or permanent diversions with the authority of the controlling body of that road, right of way or utility, and the Authority shall, upon written request from the Contractor, initiate and undertake at the Contractor's cost, legal proceedings for acquisition of any right of way necessary for such diversion.

9.2 Shifting of obstructing utilities

The Contractor shall, subject to Applicable Laws and with assistance of the Authority, undertake shifting of any utility (including electric lines, water pipes and telephone cables), to an appropriate location or alignment, if such utility or obstruction adversely affects the execution of Works or Maintenance of the Project Tunnel in accordance with this Agreement in accordance with applicable standards and specifications of concerned utility owning entity.

The work towards shifting of utilities shall be treated as Change of Scope. The Contractor shall execute such utility shifting works under the supervision of utility owning agency and Independent Engineer (IE) in accordance with the provision of Agreement. The Authority will provide assistance to the Contractor for obtaining the estimates for shifting of such utilities from the entity owning such electric lines, water pipes or telephone cables, as the case may be. The cost of utility shifting shall be based on the estimates given by the utility-owning agencies, and shall be paid as per actuals by the Authority to the Contractor. Only supervision charges shall be paid by the Authority to the utility-owning entity.

In the event of any delay in shifting thereof, the Contractor shall be responsible for failure to perform any of its obligations hereunder if such failure is a direct consequence of delay on the part of the entity owning such electric lines, water pipes or telephone cables, as the case may be.

The dismantled material/scrap of existing Utility to be shifted/dismantled shall belong to the Contractor who would be free to dispose-off the dismantled material as deemed fit by them.

The work of shifting of utilities can be taken up by the Contractor any time after signing of the Agreement.

9.3 New utilities

(i) The Contractor shall allow, subject to the permission from the Authority and such conditions as the Authority may specify, access to, and use of the Site for laying telephone lines, water pipes, electricity lines/ cables or other public utilities. Where such access or use causes any financial loss to the Contractor, it may require the user of the Site to pay compensation or damages as per Applicable Laws. For the avoidance of doubt, it is agreed that use of the Site under this Clause 9.3 shall not in any manner relieve the Contractor of its obligation to construct and maintain the Project Road in

accordance with this Agreement and any damage caused by such use shall be restored forthwith at the cost of the Authority.

(ii) The Authority may, by notice, require the Contractor to connect any adjoining road to the Project Road, and the connecting portion thereof falling within the Site shall be constructed by the Contractor at the Authority's cost in accordance with Article 10.

(iii) The Authority may by notice require the Contractor to connect, through a paved road, any adjoining service station, hotel, motel or any other public facility or amenity to the Project Road, whereupon the connecting portion thereof that falls within the Site shall be constructed by the Contractor on payment of the cost. The cost to be paid by the Authority to the Contractor shall be determined by the Authority's Engineer. For the avoidance of doubt, in the event such road is to be constructed for the benefit of any entity, the Authority may require such entity to make an advance deposit with the Contractor or the Authority, as the case may be, of an amount equal to the estimated cost as determined by the Authority's Engineer and such advance shall be adjusted against the cost of construction as determined by the Authority's Engineer hereunder.

(iv) In the event construction of any Works is affected by a new utility or works undertaken in accordance with this Clause 9.3, the Contractor shall be entitled to a reasonable Time Extension as determined by the Authority's Engineer.

9.4 Felling of trees

The Authority shall assist the Contractor in obtaining the Applicable Permits for felling of trees in non-forest area to be identified by the Authority for this purpose if, and only if, such trees cause a Material Adverse Effect on the construction or maintenance of the Project Road. The Contractor shall fell these trees as per the Permits obtained. The cost of such felling shall be borne by the Authority and in the event of any delay in felling thereof for reasons beyond the control of the Contractor; it shall be excused for failure to perform any of its obligations hereunder if such failure is a direct consequence of delay in the felling of trees. The Parties hereto agree that the felled trees shall be deemed to be owned by the Authority and shall be disposed in such manner and subject to such conditions as the Authority may in its sole discretion deem appropriate. For the avoidance of doubt, the Parties agree that if any felling of trees hereunder is in a forest area, the Applicable Permit thereof shall be procured by the Authority within the time specified in the Agreement.

9.5 Dismantling of structures

The Contractor shall at its own cost dismantle the structures in the acquired lands including those on patta lands, abadi lands, assigned lands, etc. the compensation for which, was paid by the Authority to the land owners and the lands were handed over to the Contractor as per Schedule B-I. The Contractor shall, at its own cost, dispose of the dismantled material in its sole discretion as deemed appropriate, while complying with all environmental guidelines and regulations and clear the Site for undertaking construction. In the event of any delay in dismantling of structures thereof for reasons beyond the control of the Contractor, the Contractor shall be entitled to Damages in a sum calculated in accordance with the formula specified in Clause 8.3 (i) for the period

of delay, and to the Time Extension in accordance with Clause 10.5 for and in respect of the part(s) of the Works affected by such delay; provided that if the delays involve any time overlaps, the overlaps shall not be additive.

9.6 Development Period

The Contractor may commence pre-construction activities like utility shifting, boundary wall construction or any other activity assigned to the Contractor by the Authority to enable construction of the Project Road immediately after signing of the Agreement, to the extent that such work is ready for execution. The Parties agree that these works may be taken up and completed to the extent feasible by the Contractor, before declaration of the Appointed Date, but no claim against the Authority for delay shall survive during this period and that the undertaking of these works by the Contractor shall not count towards the Scheduled Construction Period of the project which starts counting only from the Appointed Date. No construction activity of the Project Road shall be undertaken during the development period.

Article 10

Design and Construction of the Project Road

10.1 Obligations prior to commencement of Works

(i) Within 20 (twenty) days of the Appointed Date, the Contractor shall:

(a) appoint its representative, duly authorised to deal with the Authority in respect of all matters under or arising out of or relating to this Agreement;

(b) appoint a design director (the "**Design Director**") who will head the Contractor's design unit and shall be responsible for surveys, investigations, collection of data, and preparation of preliminary and detailed designs;

(c) undertake and perform all such acts, deeds and things as may be necessary or required before commencement of Works under and in accordance with this Agreement, the Applicable Laws and Applicable Permits; and

(d) make its own arrangements for quarrying of materials needed for the Project Road under and in accordance with the Applicable Laws and Applicable Permits.

(ii) The Authority shall, appoint an engineer (the **"Authority's Engineer"**) before the Appointed Date to discharge the functions and duties specified in this Agreement, and shall notify to the Contractor the name, address and the date of appointment of the Authority's Engineer forthwith.

(iii) Within 30 (thirty) days of the Appointed Date, the Contractor shall submit to the Authority and the Authority's Engineer a programme (the **"Programme"**) for the Works, developed using networking techniques, for review and consent of the Engineer, giving the following details:

(a) Part I : Contractor's organisation for the Project, the general methods and arrangements for design and construction, environmental management plan, Quality Assurance Plan including design quality plan, traffic management and safety plan covering safety of users and workers during construction (including use of 'ROBOTS' for diversion and control of traffic), Contractor's key personnel and equipment.

(b) Part II : Programme for completion of all stages of construction given in Schedule-H and Project Milestones of the Works as specified in Project Completion Schedule set forth in Schedule-J. The Programme shall include:

i. the order in which the Contractor intends to carry out the Works, including the anticipated timing of design and stages of Works;

ii. the periods for reviews under Clause 10.2;

iii. the sequence and timing of inspections and tests specified in this Agreement; and

iv. the particulars for the pre-construction reviews and for any other submissions, approvals and consents specified in the Agreement.

The Contractor shall submit a revised Programme whenever the previous Programme is inconsistent with the actual progress or with the Contractor's obligations.

(c) Part III : Monthly cash flow forecast.

(iv) The Contractor shall compute, on the basis of the Drawings prepared in accordance with Clause 10.2 (iv), and provide to the Authority's Engineer, the length, area and numbers, as the case may be, in respect of the various items of work specified in Schedule-H and comprising the Scope of the Project. The Parties expressly agree that these details shall form the basis for estimating the interim payments for the Works in accordance with the provisions of Clause 19.3. For the avoidance of doubt, the sum of payments to be computed in respect of all the items of work shall not exceed the Contract Price, as may be adjusted in accordance with the provisions of this Agreement.

(v) The Contractor shall appoint a safety consultant (the **"Safety Consultant"**) to carry out a safety audit at the design stage of the Project Road in accordance with the Applicable Laws and Good Industry Practice. The Safety Consultant shall be appointed after proposing to the Authority a panel of three (3) names of qualified and experienced firms from which the Authority may choose one (1) to be the Safety Consultant. Provided, however, that if the panel is not acceptable to the Authority and the reasons for the same are furnished to the Contractor, the Contractor shall propose to the Authority a revised panel of three (3) names from the firms empanelled as safety consultants by the [Ministry of Road Transport and Roads] for obtaining the consent of the Authority. The Contractor shall also obtain the consent of the Authority for the key personnel of the Safety Consultant who shall have adequate experience and qualifications in safety audit of the Road projects. The Authority shall, within 15 (fifteen) days of receiving a proposal from the Contractor hereunder, convey its decision, with reasons, to the Contractor, and if no such decision is conveyed within the said period, the Contractor may proceed with engaging of the Safety Consultant.

(vi) The safety audit pursuant to Clause 10.1 (v) shall be carried out by the Safety Consultant in respect of all such design details that have a bearing on safety of Users as well as pedestrians and animals involved in or associated with accidents. The recommendations of the Safety Consultant shall be incorporated in the design of the Project Road and the Contractor shall forward to the Authority's Engineer a certificate to this effect together with the recommendations of the Safety Consultant. In the event that any works required by the Safety Consultant shall fall beyond the scope of Schedule-B, Schedule-C or Schedule-D, the Contractor shall make a report thereon and seek the instructions of the Authority for Change in Scope. For the

avoidance of doubt, the Safety Consultant to be engaged by the Contractor shall be independent of the design and implementation team of the Contractor.

10.2 Design and Drawings

(i) Design and Drawings shall be developed in conformity with the Specifications and Standards set forth in Schedule-D. In the event, the Contractor requires any relaxation in design standards due to restricted Right of Way in any section, the alternative design criteria for such section shall be provided for review and approval of the Authority's Engineer.

(ii) The Contractor shall appoint a proof check consultant (the "**Proof Consultant**") after proposing to the Authority a panel of three (3) names of qualified and experienced firms from whom the Authority may choose one (1) to be the Proof Consultant. Provided, however, that if the panel is not acceptable to the Authority and the reasons for the same are furnished to the Contractor, the Contractor shall propose to the Authority a revised panel of three (3) names from the firms empaneled as proof consultants by the [Ministry of Road Transport and Roads] for obtaining the consent of the Authority. The Contractor shall also obtain the consent of the Authority for two (2) key personnel of the Proof Consultant who shall have adequate experience and qualifications in Roads and bridges respectively. The Authority shall, within 15 (fifteen) days of receiving a proposal from the Contractor hereunder, convey its decision, with reasons, to the Contractor, and if no such decision is conveyed within the said period, the Contractor may proceed with engaging of the Proof Consultant.

(iii) The Proof Consultant shall:

(a) evolve a systems approach with the Design Director so as to minimise the time required for final designs and construction drawings; and

(b) proof check the detailed calculations, drawings and designs, which have been approved by the Design Director.

(iv) In respect of the Contractor's obligations with respect to the design and Drawings of the Project Road as set forth in Schedule-I, the following shall apply:

(a) The Contractor shall prepare and submit, with reasonable promptness and in such sequence as is consistent with the Project Completion Schedule, three (3) copies each of the design and Drawings, duly certified by the Proof Consultant, to the Authority's Engineer for its approval. Provided, however, that in respect of Major Bridges and Structures, the Authority's Engineer may require additional drawings for approval in accordance with Good Industry Practice.

(b) by submitting the Drawings for review and approval to the Authority's Engineer, the Contractor shall be deemed to have represented that it has determined and verified that the design and engineering, including field construction criteria related thereto, are in conformity with the Scope of the Project, the Specifications and Standards and the Applicable Laws;

(c) within 15 (fifteen) days of the receipt of the Drawings, the Authority's Engineer shall review the same and convey its approval/observations to the Contractor with particular reference to their conformity or otherwise with the Scope of the Project and the Specifications and Standards. Provided, however that in case of a major bridge or structure, the aforesaid period of 15 (fifteen) days may be extended up to 30 (thirty) days;

(d) if the aforesaid observations of the Authority's Engineer indicate that the Drawings are not in conformity with the Scope of the Project or the Specifications and Standards, such Drawings shall be revised by the Contractor in conformity with the provisions of this Agreement and resubmitted to the Authority's Engineer for review and approval. The Authority's Engineer shall give its observations, if any, within 10 (ten) days of receipt of the revised Drawings. In the event the Contractor fails to revise and resubmit such Drawings to the Authority's Engineer for review/approval as aforesaid, the Authority's Engineer may withhold the payment for the affected works in accordance with the provisions of Clause 19.5 (iv). If the Contractor disputes any decision, direction or determination of the Authority's Engineer hereunder, the Dispute shall be resolved in accordance with the Dispute Resolution Procedure;

(e) no review/approval and/or observation of the Authority's Engineer and/or its failure to review/approval and/or convey its observations on any Drawings shall relieve the Contractor of its obligations and liabilities under this Agreement in any manner nor shall the Authority's Engineer or the Authority be liable for the same in any manner; and if errors, omissions, ambiguities, inconsistencies, inadequacies or other Defects are found in the Drawings, they and the construction works shall be corrected at the Contractor's cost, notwithstanding any approval under this Article 10;

(f) the Contractor shall be responsible for delays in submitting the Drawing as set forth in Schedule-I caused by reason of delays in surveys and field investigations, and shall not be entitled to seek any relief in that regard from the Authority; and

(g) the Contractor warrants that its designers, including any third parties engaged by it, shall have the required experience and capability in accordance with Good Industry Practice and it shall indemnify the Authority against any damage, expense, liability, loss or claim, which the Authority might incur, sustain or be subject to arising from any breach of the Contractor's design responsibility and/or warranty set out in this Clause.

(h) the Contractor shall ensure that all the designs and drawings shall be approved from the Authority's Engineer within 90 days (ninety) from the Appointed Date.

(v) Any cost or delay in construction arising from review/approval by the Authority's Engineer shall be borne by the Contractor.

(vi) Works shall be executed in accordance with the Drawings provided by the Contractor in accordance with the provisions of this Clause 10.2 and the approval of the Authority's Engineer thereon as communicated pursuant to the provisions of sub- Clause (c) & (d) of Clause 10.2 (iv). Such Drawings shall not be amended or altered without prior written notice to the Authority's Engineer. If a Party becomes aware of an error or defect of a technical nature in the design or Drawings, that Party shall promptly give notice to the other Party of such error or defect.

(vii) Within 90 (ninety) days of the Project Completion Date, the Contractor shall furnish to the Authority and the Authority's Engineer a complete set of as- built Drawings, in 2 (two) hard copies and in micro film form or in such other medium as may be acceptable to the Authority, reflecting the Project Road as actually designed, engineered and constructed, including an as-built survey illustrating the layout of the Project Road and setback lines, if any, of the buildings and structures forming part of Project Facilities.

10.3 Construction of the Project Road

(i) The Contractor shall construct the Project Road as specified in Schedule- B and Schedule-C, and in conformity with the Specifications and Standards set forth in Schedule-D. The Contractor shall be responsible for the correct positioning of all parts of the Works, and shall rectify any error in the positions, levels, dimensions or alignment of the Works. The [547*th (five hundred and forty-seventh) day*] from the Appointed Date shall be the scheduled completion date (the **"Scheduled Completion Date"**) and the Contractor agrees and undertakes that the construction shall be completed on or before the Scheduled Completion Date, including any extension thereof.

(ii) The Contractor shall construct the Project Road in accordance with the Project Completion Schedule set forth in Schedule-J. In the event that the Contractor fails to achieve any Project Milestone or the Scheduled Completion Date within a period of 30 (thirty) days from the date set forth in Schedule-J, unless such failure has occurred due to Force Majeure or for reasons solely attributable to the Authority, it shall pay Damages to the Authority of a sum calculated at the rate of 0.05% (zero point zero five percent) of the Contract Price for delay of each day reckoned from the date specified in Schedule –J and until such Project Milestone is achieved or the Project Road is completed; provided that if the period for any or all Project Milestones or the Scheduled Completion Date is extended in accordance with the provisions of this Agreement, the dates set forth in Schedule-J shall be deemed to be modified accordingly and the provisions of this Agreement shall apply as if Schedule-J has been amended as above; provided further that in the event the Project Road is completed within or before the Scheduled Completion Date including any Time Extension, applicable for that work or section, the Damages paid under this Clause10.3 (ii) shall be refunded by the Authority to the Contractor, but without any interest thereon.

The Parties agree that for determining achievement or delays in completion of the Project Milestones or the Project on the due date, the works affected due to delay in providing the site for which time extension has been granted beyond the Scheduled Completion Date will be excluded. For example on the due date to achieve the Project Milestone-I (i.e., Stage Payments of 10% (ten percent) of Contract Price on 180th (one hundred and eighty) day from the Appointed Date), if 5% (five percent) of the project length corresponding to the Project Milestone-I is not handed over or lately handed over resulting in the extension of completion of this 5% (five percent) length beyond Scheduled Completion Date, Stage Payment of 10% X 0.95 = 9.5% only is to be achieved by 180th (one hundred and eighty) day.

For the avoidance of doubt, it is agreed that recovery of Damages under this Clause 10.3 (ii) shall be without prejudice to the rights of the Authority under this Agreement including the right of Termination thereof. The Parties further agree that Time Extension hereunder shall only be reckoned for and in respect of the affected Works as specified in Clause 10.5 (ii).

(iii) The Authority shall notify the Contractor of its decision to impose Damages in pursuance with the provisions of this Clause 10.3. Provided that no deduction on account of Damages shall be effected by the Authority without notifying the Contractor of its decision to impose the Damages, and taking into consideration the representation, if any, made by the Contractor within 20 (twenty) days of such notice. The Parties expressly agree that the total amount of Damages under Clause 10.3 (ii) shall not exceed 10% (ten percent) of the Contract Price. If the damages exceed 10% (ten percent) of the Contract Price, the Contractor shall be deemed to be in default of this agreement having no cure and the Authority shall be entitled to terminate this Agreement by issuing a Termination Notice in accordance with the provisions of Clause 23.1 (ii).

(iv) In the event that the Contractor fails to achieve the Project Completion within a period of 90 (ninety) days from the Schedule Completion Date set forth in Schedule-J, unless such failure has occurred due to Force Majeure or for reasons solely attributable to the Authority, the contractor shall be deemed to be ineligible for bidding any future projects of the Authority, both as the sole party or as one of the parties of Joint Venture/ Consortium during the period from Scheduled Completion Date to issuance of Completion Certificate. This restriction is applicable if the contract value of the delayed project is not less than Rs. 300 Crore.

10.4 Maintenance during Construction Period

(i) During the Construction Period, the Contractor shall maintain, at its cost, the existing lane(s) of the Project Road so that the traffic worthiness and safety thereof are at no time materially inferior as compared to their condition on Appointed Date, and shall undertake the necessary repair and maintenance works for this purpose; provided that the Contractor may, at its cost, interrupt and divert the flow of traffic if such interruption and diversion is necessary for the efficient progress of Works and conforms to Good Industry Practice; provided further that such interruption and

diversion shall be undertaken by the Contractor only with the prior written approval of the Authority's Engineer which approval shall not be unreasonably withheld. For the avoidance of doubt, it is agreed that the Contractor shall at all times be responsible for ensuring safe operation of the Project Road. It is further agreed that in the event the Project includes construction of a bypass or tunnel and realignment of the existing carriageway, the Contractor shall maintain the existing Road in such sections until the new Works are open to traffic.

(ii) Notwithstanding anything to the contrary contained in this Agreement, in the event of default by the Contractor in discharging the obligations specified in Clause 10.4 (i) above, the Authority shall get these maintenance works completed in the manner recommended by the Authority's Engineer to avoid public inconvenience at the risk and cost of the Contractor in order to keep the road in traffic worthy condition.

10.5 Extension of time for completion

(i) Without prejudice to any other provision of this Agreement for and in respect of extension of time, the Contractor shall be entitled to extension of time in the Project Completion Schedule (the **"Time Extension"**) to the extent that completion of any Project Milestone is or will be delayed by any of the following, namely:

(a) delay in providing the Right of Way of Construction Zone, environmental clearances or approval of railway authorities, specified in Clause 3.1 (iv);

(b) Change of Scope (unless an adjustment to the Scheduled Completion Date has been agreed under Article 13);

(c) occurrence of a Force Majeure Event;

(d) any delay, impediment or prevention caused by or attributable to the Authority, the Authority's personnel or the Authority's other contractors on the Site; and

(e) any other cause or delay which entitles the Contractor to Time Extension in accordance with the provisions of this Agreement.

(ii) The Contractor shall, no later than 15 (fifteen) business days from the occurrence of an event or circumstance specified in Clause 10.5 (i), inform the Authority's Engineer by notice in writing, with a copy to the Authority, stating in reasonable detail with supporting particulars, the event or circumstances giving rise to the claim for Time Extension in accordance with the provisions of this Agreement. Provided that the period of 15 (fifteen) business days shall be calculated from the date on which the Contractor became aware, or should have become aware, of the occurrence of such an event or circumstance.

Provided further that notwithstanding anything to the contrary contained in this Agreement, Time Extension shall be due and applicable only for the Works which are affected by the aforesaid events or circumstances and shall not in any manner affect the Project Completion Schedule for and in respect of the Works which are not affected hereunder.

(iii) On the failure of the Contractor to issue to the Authority's Engineer a notice in accordance with the provisions of Clause 10.5 (ii) within the time specified therein, the Contractor shall not be entitled to any Time Extension and shall forfeit its right for any such claims in future. For the avoidance of doubt, in the event of failure of the Contractor to issue notice as specified in this clause 10.5 (iii), the Authority shall be discharged from all liability in connection with the claim.

(iv) The Authority's Engineer shall, on receipt of the claim in accordance with the provisions of Clause 10.5 (ii), examine the claim expeditiously within the time frame specified herein. In the event the Authority's Engineer requires any clarifications to examine the claim, the Authority's Engineer shall seek the same within 15 (fifteen) days from the date of receiving the claim. The Contractor shall, on receipt of the communication of the Authority's Engineer requesting for clarification, furnish the same to the Authority's Engineer within 10 (ten) days thereof. The Authority's Engineer shall, within a period of 30 (thirty) days from the date of receipt of such clarifications, forward in writing to the Contractor its determination of Time Extension.

Provided that when determining each extension of time under this Clause 10.5, the Authority's Engineer shall review previous determinations and may increase, but shall not decrease, the total Time Extension.

(v) If the event or circumstance giving rise to the notice has a continuing effect:

(a) a fully detailed claim shall be considered as interim;

(b) the Contractor shall, no later than 10 (ten) days after the close of each month, send further interim claims specifying the accumulated delay, the extension of time claimed, and such further particulars as the Authority's Engineer may reasonably require; and

(c) the Contractor shall send a final claim within 30 (thirty) days after the effect of the event or the circumstance ceases.

Upon receipt of the claim hereunder, the Authority's Engineer shall examine the same in accordance with the provisions of Clause 10.5 (iv) within a period of 30 (thirty) days of the receipt thereof

10.6 Incomplete Works

In the event the Contractor fails to complete the Works in accordance with the Project Completion Schedule, including any Time Extension granted under this Agreement, the Contractor shall endeavour to complete the balance work expeditiously and shall pay Damages to the Authority in accordance with the provisions of Clause 10.3 (ii) for delay of each day until the Works are completed in accordance with the provisions of this Agreement. Recovery of Damages under this Clause shall be without prejudice to the rights of the Authority under this Agreement including the right to termination under Clause 23.1.

10.7 Maintenance Manual

No later than 60 (sixty) days prior to the Project Completion Date, the Contractor shall, in consultation with the Authority's Engineer, evolve a maintenance manual (the **"Maintenance Manual"**) for the regular and preventive maintenance of the Project Road in conformity with the Specifications and Standards, safety requirements and Good Industry Practice, and shall provide 5 (five) copies thereof to the Authority's Engineer. The Authority's Engineer shall review the Maintenance Manual within 15 (fifteen) days of its receipt and communicate its comments to the Contractor for necessary modifications, if any.

10.8 As-Built Records

The Contractor shall prepare, and keep up to date, a complete set of as built records of the execution of the Works, showing the exact as built locations, sizes and details on the Works as executed with cross references to all relevant specifications and data sheets. These records shall be kept on the Site and shall be used exclusively for the purpose of this Sub-Clause 10.8. The Contractor shall provide 2 (two) copies of as built records to the Authority prior to the commencement of the Tests on Completion.

10.9 Contractor's Use of Authority's Documents

Intellectual property in the Authority's requirements and Specifications and Standards and all other documents and materials issued by the Authority or the Authority's Representative to the Contractor shall (as between the parties) remain the property of the Authority. The Contractor may, at its cost, copy, use and communicate any such documents for the purposes of the Contract. They shall not, without the consent of the Authority, be used, copied or communicated to a third party by the Contractor, except as necessary for the purposes of the Works under the Agreement.

Article 11

Quality Assurance, Monitoring and Supervision

11.1 Quality of Materials and workmanship

The Contractor shall ensure that the Construction, Materials and workmanship are in accordance with the requirements specified in this Agreement, Specifications and Standards and Good Industry Practice.

11.2 Quality control system

(i) The Contractor shall establish a quality control mechanism to ensure compliance with the provisions of this Agreement (the **"Quality Assurance Plan"** or **"QAP"**).

(ii) The Contractor shall, within 30 (thirty) days of the Appointed Date, submit to the Authority's Engineer its Quality Assurance Plan which shall include the following:

(a) organisation, duties and responsibilities, procedures, inspections and documentation;

(b) quality control mechanism including sampling and testing of Materials, test frequencies, standards, acceptance criteria, testing facilities, reporting, recording and interpretation of test results, approvals, check list for site activities, and proforma for testing and calibration in accordance with the Specifications for Road and Bridge Works issued by MORTH, relevant IRC specifications and Good Industry Practice; and

(c) internal quality audit system.

The Authority's Engineer shall convey its approval to the Contractor within a period of 21 (twenty-one) days of receipt of the QAP stating the modifications, if any, required, and the Contractor shall incorporate those in the QAP to the extent required for conforming with the provisions of this Clause 11.2.

(iii) The Contractor shall procure all documents, apparatus and instruments, fuel, consumables, water, electricity, labour, Materials, samples, and qualified personnel as are necessary for examining and testing the Project Assets and workmanship in accordance with the Quality Assurance Plan.

(iv) The cost of testing of Construction, Materials and workmanship under this Article 11 shall be borne by the Contractor.

11.3 Methodology

The Contractor shall, at least 15 (fifteen) days prior to the commencement of the construction, submit to the Authority's Engineer for review and consent the methodology proposed to be adopted for executing the Works, giving details of equipment to be deployed, traffic management and measures for ensuring safety. The Authority's Engineer shall complete the review and convey its consent to the

Contractor within a period of 10 (ten) days from the date of receipt of the proposed methodology from the Contractor.

11.4 Inspection and technical audit by the Authority

The Authority or any representative authorised by the Authority in this behalf may inspect and review the progress and quality of the construction of Project Road and issue appropriate directions to the Authority's Engineer and the Contractor for taking remedial action in the event the Works are not in accordance with the provisions of this Agreement.

11.5 External technical audit

(i) At any time during construction, the Authority may appoint an external technical auditor to conduct an audit of the quality of the Works. The Auditor in the presence of the representatives of the Contractor and the Authority's Engineer shall carry out the tests and/ or collect samples for testing in the laboratory. The timing, the testing equipment and the sample size of this audit shall be as decided by the Authority. The findings of the audit, to the extent accepted by the Authority, shall be notified to the Contractor and the Authority's Engineer for taking remedial action in accordance with this Agreement.

(ii) After completion of the remedial measures by the Contractor, the Auditor shall undertake a closure audit and this process will continue till the remedial measures have brought the works into compliance with the Specifications and Standards. The Contractor shall provide all assistance as may be required by the auditor in the conduct of its audit hereunder. Notwithstanding anything contained in this Clause 11.5, the external technical audit shall not affect any obligations of the Contractor or the Authority's Engineer under this Agreement.

11.6 Inspection of construction records

The Authority shall have the right to inspect the records of the Contractor relating to the Works.

11.7 Monthly progress reports

During the Construction Period, the Contractor shall, no later than 10 (ten) days after the close of each month, furnish to the Authority and the Authority's Engineer a monthly report on progress of the Works and shall promptly give such other relevant information as may be required by the Authority's Engineer.

The Contractor agrees that reporting under this Clause 11.7 shall continue until the date of the completion of the Works. Each report shall include:

(a) an executive summary;

(b) charts showing the status of Contractor's documents, construction and manufacturing and environmental works;

(c) details of work subcontracted and the performance of Sub-contractors;

(d) for the construction of each main part of the Works, the extent of progress (both quantity and percentage of the whole), the actual or expected dates of commencement, anticipated completion date of the activity, Contractor's inspections and tests;

(e) records of manpower and Contractor's equipment on the Site; alongwith a detailed report indicating the locations and movement of all construction vehicles by way of installing a functional Global Positioning System (GPS) in each vehicle, which shall include, but not limited tom the following information:

i. Real-time location data of each construction vehicle.

ii. Timestamps indicating the start and end times of vehicle movements.

iii. Mileage covered by each vehicle.

The Contractor shall be responsible for ensuring the accuracy and integrity of the GPS tracking data.

(f) copies for that month of quality assurance documents, test results and certificates;

(g) safety statistics, accident data collection including details of any hazardous incidents and activities relating to environmental aspects and public relations;

(h) comparisons of actual and planned progress, with details of any aspects which may jeopardise the completion in accordance with the Agreement, and the measures being (or to be) adopted to overcome such aspects;

(i) details of any unresolved disputes or claims, in relation to the Project;

(j) details of any revision to the cash flow estimate, together with a copy of the revised cash flow estimate;

(k) status of various Applicable Permits and compliance of conditions therein;

(l) details of various royalty payment and insurances required to be taken by the Contractor; and

(m) such other reports as may be required by the Authority for enabling the Authority to comply with its obligations under the other Project contracts.

(n) details of defects by the Authority;

(o) change in emission of any sewage or effluent of any nature whatsoever, whether qualitatively or quantitatively;

(p) any Material Adverse Effect;

(q) declaration towards compliance with Applicable Laws including but not limited to environmental and labour legislations;

(r) declaration specifying compliance with all Manuals provided to the Contractor; and

(s) any change in the flow of traffic on the existing Project Road.

11.8 Inspection

(i) The Authority's Engineer and its authorised representative shall at all reasonable times:

(a) have full access to all parts of the Site and to all places from which natural Materials are being obtained for use in the Works; and

(b) during production, manufacture and construction at the Site and at the place of production, be entitled to examine, inspect, measure and test the Materials and workmanship, and to check the progress of manufacture of Materials.

(ii) The Contractor shall give the Authority's Engineer and its authorised agents access, facilities and safety equipment for carrying out their obligations under this Agreement.

(iii) The Authority's Engineer shall submit a monthly inspection report (the "**Inspection Report**") to the Authority and the Contractor bringing out the results of inspections and the remedial action taken by the Contractor in respect of Defects or deficiencies. For the avoidance of doubt, such inspection or submission of Inspection Report by the Authority's Engineer shall not relieve or absolve the Contractor of its obligations and liabilities under this Agreement in any manner whatsoever.

11.9 Samples

The Contractor shall submit the following samples of Materials and relevant information to the Authority's Engineer for pre-construction review:

(a) manufacturer's test reports and standard samples of manufactured Materials; and

(b) samples of such other Materials as the Authority's Engineer may require.

11.10 Tests

(i) For determining that the Works conform to the Specifications and Standards, the Authority's Engineer shall require the Contractor to carry out or cause to be carried out tests, at such time and frequency and in such manner as specified in this Agreement, and in accordance with Good Industry Practice for quality management. The Authority's Engineer shall witness all the quality control tests carried out by the Contractor at its site laboratory/fields/plants. These includes tests for all materials, mixes, products, etc. Authority's Engineer shall also witness all tests of finished products like bearing in the manufacturers' laboratory as mandate in respective standards. Authority's Engineer will also conduct review of quality control documents in respect of factory manufactured material/finished products, etc. as per IRC:SP:112.

(ii) In the event that results of any tests conducted under this Clause 11.10 establish any Defects or deficiencies in the Works, the Contractor shall carry out remedial measures and furnish a report to the Authority's Engineer in this behalf. The Authority's Engineer shall require the Contractor to carry out or cause tests to be carried out to determine that such remedial measures have brought the Works into compliance with the

Specifications and Standards, and the procedure shall be repeated until such Works conform to the Specifications and Standards. For the avoidance of doubt, the cost of such tests and remedial measures in pursuance thereof shall be solely borne by the Contractor.

11.11 Examination of work before covering up

In respect of the work which the Authority's Engineer is entitled to examine, inspect, measure and/or test before it is covered up or put out of view or any part of the work is placed thereon, the Contractor shall give notice to the Authority's Engineer whenever any such work is ready and before it is covered up. The Authority's Engineer shall then either carry out the examination, inspection or testing without unreasonable delay, or promptly give notice to the Contractor that the Authority's Engineer does not require to do so. Provided, however, that if any work is of a continuous nature where it is not possible or prudent to keep it uncovered or incomplete, the Contractor shall notify the schedule of carrying out such work to give sufficient opportunity, not being less than 3 (three) business days' notice, to the Authority's Engineer to conduct its inspection, measurement or test while the work is continuing. Provided further that in the event the Contractor receives no response from the Authority's Engineer within a period of 3 (three) business days from the date on which the Contractor's notice hereunder is delivered to the Authority's Engineer, the Contractor shall be entitled to assume that the Authority's Engineer would not undertake the said inspection.

11.12 Rejection

If, as a result of an examination, inspection, measurement or testing, any Plant, Materials, design or workmanship is found to be defective or otherwise not in accordance with the provisions of this Agreement, the Authority's Engineer shall reject the Plant, Materials, design or workmanship by giving notice to the Contractor, with reasons. The Contractor shall then promptly make good the Defect and ensure that the rejected item complies with the requirements of this Agreement.

If the Authority's Engineer requires the Plant, Materials, design or workmanship to be retested, the tests shall be repeated under the same terms and conditions, as applicable in each case. If the rejection and retesting cause the Authority to incur any additional costs, such cost shall be recoverable by the Authority from the Contractor; and may be deducted by the Authority from any monies due to be paid to the Contractor.

11.13 Remedial work

(i) Notwithstanding any previous test or certification, the Authority's Engineer may instruct the Contractor to:

(a) remove from the Site and replace any Plant or Materials which are not in accordance with the provisions of this Agreement;

(b) remove and re-execute any work which is not in accordance with the provisions of this Agreement and the Specification and Standards; and

(c) execute any work which is urgently required for the safety of the Project Road,

whether because of an accident, unforeseeable event or otherwise; provided that in case of any work required on account of a Force Majeure Event, the provisions of Clause 21.6 shall apply.

(ii) If the Contractor fails to comply with the instructions issued by the Authority's Engineer under Clause 11.13 (i), within the time specified in the Authority's Engineer's notice or as mutually agreed, the Authority's Engineer may advise the Authority to have the work executed by another agency. The cost so incurred by the Authority for undertaking such work shall, without prejudice to the rights of the Authority to recover Damages in accordance with the provisions of this Agreement, be recoverable from the Contractor and may be deducted by the Authority from any monies due to be paid to the Contractor.

11.14 Delays during construction

Without prejudice to the provisions of Clause 10.3 (ii), in the event the Contractor does not achieve any of the Project Milestones or the Authority's Engineer shall have reasonably determined that the rate of progress of Works is such that Completion of the Project Road is not likely to be achieved by the end of the Scheduled Completion Date, it shall notify the same to the Contractor, and the Contractor shall, within 15 (fifteen) days of such notice, by a communication inform the Authority's Engineer in reasonable detail about the steps it proposes to take to expedite progress and the period within which it shall achieve the Project Completion Date.

11.15 Quality control records and Documents

The Contractor shall hand over a copy of all its quality control records and documents to the Authority's Engineer before the Completion Certificate is issued pursuant to Clause 12.2. The Contractor shall submit Road Signage Plans to the Authority Engineer for approval at least 6 (six) months prior to expected completion of Project Road.

11.16 Video recording

During the Construction Period, the Contractor shall provide to the Authority for every calendar quarter, a video recording, which will be compiled into a 3 (three)- hour compact disc or digital video disc, as the case may be, covering the status and progress of Works in that quarter. The video recording shall be provided to the Authority no later than 15 (fifteen) days after the close of each quarter after the Appointed Date.

11.17 Suspension of unsafe Construction Works

(i) Upon recommendation of the Authority's Engineer to this effect, the Authority may by notice require the Contractor to suspend forthwith the whole or any part of the Works if, in the reasonable opinion of the Authority's Engineer, such work threatens the safety of the Users and pedestrians.

(ii) The Contractor shall, pursuant to the notice under Clause 11.17 (i), suspend the Works or any part thereof for such time and in such manner as may be specified by the Authority and thereupon carry out remedial measures to secure the safety of suspended works, the Users and pedestrians. The Contractor may by notice require the

Authority's Engineer to inspect such remedial measures forthwith and make a report to the Authority recommending whether or not the suspension hereunder maybe revoked. Upon receiving the recommendations of the Authority's Engineer, the Authority shall either revoke such suspension or instruct the Contractor to carry out such other and further remedial measures as may be necessary in the reasonable opinion of the Authority, and the procedure set forth in this Clause 11.17 shall be repeated until the suspension hereunder is revoked.

(iii) Subject to the provisions of Clause 21.6, all reasonable costs incurred for maintaining and protecting the Works or part thereof during the period of suspension (the "**Preservation Costs**"), shall be borne by the Contractor; provided that if the suspension has occurred as a result of any breach of this Agreement by the Authority, the Preservation Costs shall be borne by the Authority.

(iv) If suspension of Works is for reasons not attributable to the Contractor, the Authority's Engineer shall determine any Time Extension to which the Contractor is reasonably entitled.

11.18 Staff and Labour

(i) Engagement of Staff and Labour

(a) The Contractor shall make its own arrangements for the engagement of all personnel and labour, local or otherwise, and for their payment, housing, feeding and transport.

(b) The Contractor has verified/ shall verify the identity and address of all its employees and officials related to the Works by collecting necessary documentary proof.

(c) The Contractor shall seek a self-declaration from its employees that they have not been convicted of any criminal offence by any court and if any criminal proceedings/charge-sheets have been pending/filed against them. The Contractor shall not employ persons with criminal track record on the project. In cases where it comes to notice later that the employee concerned has concealed any such fact in his self-declaration or commits a criminal offence during the course of his employment, the Contractor shall remove such person from the project

(d) Deleted.

(e) The employees and personnel of the Contractor shall work under the supervision, control and direction of the Contractor and the Contractor shall be solely responsible for all negotiations with its employees and personnel relating to their salaries and benefits, and shall be responsible for assessments and monitoring of performance and for all disciplinary matters. All employees / personnel, executives engaged by the Contractor shall be in sole employment of the Contractor and the Contractor shall be solely responsible for their salaries, wages, statutory payments, etc. and under no circumstances the personnel shall be deemed to be the employees of the Authority. Under no circumstances the Authority shall be liable for any payment or claim or

compensation of any nature to the employees and personnel of the Contractor.

(ii) Returns of Labour

(a) The Contractor shall deliver to the Authority a detailed return in such form and at such intervals as the Authority may prescribe, showing the details including names, payment details and terms of appointment of the several classes of labour employed by the Contractor from time to time for the Works. The Contractor shall, in its returns certify that all dues of the workers or labour have been fully paid.

(b) The Authority is entitled to witness labour payments made or to be made by the Contractor. If the Contractor defaults in its obligations for making any payments under the labour laws, the Employer may make the relevant payments. Any sum equal to any amount paid by the Employer under this Sub-Sub-Clause 9.2 shall be immediately due as a debt from the Contractor to the Employer and until payment/ set off shall carry interest at 18% per annum. For this purpose, it is agreed between the parties that debt due aforesaid shall be set off immediately out the running account bills of the Contractor under this Agreement.

(iii) Persons in the Service of Others

The Contractor shall not recruit, or attempt to recruit from amongst persons in the service of the Authority.

(iv) Labour Laws

(a) The Contractor shall obtain all relevant labour registrations and comply with all relevant labour laws applying to its employees, and shall duly pay them and afford to them all their legal rights.

(b) The Contractor shall make all deductions of tax at source and all contributions to the Payment of Gratuity, Provident Fund (including Employees' contribution) and Employees' State Insurance Scheme as may be required by Applicable Laws and deposit the aforesaid contributed amount with the appropriate authority/(s).

(c) The Contractor shall require all personnel engaged in the Works to obey all Applicable Laws and regulations. The Contractor shall permit Authority to witness labour payments for the Contractors direct labour, or the Subcontractors labour. The Contractor shall ensure that all its Subcontractors strictly comply with all labour laws.

(d) Documentary evidence confirming compliance with Sub-Clause 12.4, as may be required from time to time, shall be provided to the Employer's Representative.

(e) The Employer shall not be liable for any delay/default of the Contractor in compliance of the labour laws.

(v) Facilities for Staff and Labour

The Contractor shall provide and maintain all necessary accommodation and welfare facilities for personnel engaged for the Works. The Contractor shall not permit any personnel engaged for the Works to maintain any temporary or permanent living quarters within the structures forming part of the Works.

(vi) Health And Safety

All necessary precautions shall be taken by the Contractor to ensure the health and safety of staff and labour engaged for the Works. The Contractor shall, in collaboration with and to the requirements of the local health authorities, ensure that para-medical staff, first aid facilities, ambulance service are available on the Site at all times, and that suitable arrangements are made for all necessary welfare and hygiene requirements and for the prevention of epidemics. The Contractor shall appoint a safety officer to be responsible for the safety of personnel on the Site. This safety officer shall be qualified for his work and shall have the authority to issue instructions concerning safety and take protective measures to prevent accidents. The Contractor shall maintain records and make reports concerning health, safety and welfare of personnel, and damage to property, in such manner as the Authority may reasonably require.

(vii) Contractor's Personnel

The Contractor shall employ only personnel who are appropriately qualified, skilled and experienced in their respective trades or occupations. The Authority may require the Contractor to remove any personnel engaged for the Works, who in the opinion of the Authority:

(a) has engaged in any misconduct;

(b) is incompetent or negligent in the performance of his duties;

(c) fails to conform with any provisions of the Contract;

(d) engages in any conduct which is prejudicial to safety, health, or the protection of the environment; or

(e) makes errors in the discharge of his functions.

If appropriate and required by the Employer, the Contractor shall then appoint (or cause to be appointed) a suitable replacement person.

(viii) Disorderly Conduct

The Contractor shall at all times take all reasonable precautions to prevent any unlawful, riotous or disorderly conduct by or amongst its personnel, and to preserve peace and protection of people and property in the neighbourhood of the Works.

Article 12

Completion Certificate

12.1 Tests on Completion

(i) At least 30 (thirty) days prior to the likely completion of the Project Road, or a Section thereof, the Contractor shall notify the Authority's Engineer of its intent to subject the Project Road or a Section thereof, to Tests. The date and time of each of the Tests shall be determined by the Authority's Engineer in consultation with the Contractor and notified to the Authority who may designate its representative to witness the Tests. The Contractor shall either conduct the Tests as directed by the Authority's Engineer or provide such assistance as the Authority's Engineer may reasonably require for conducting the Tests. In the event of the Contractor and the Authority's Engineer failing to mutually agree on the dates for conducting the Tests, the Contractor shall fix the dates by giving not less than 10 (ten) days' notice to the Authority's Engineer.

(ii) All Tests shall be conducted in accordance with Schedule-K. The Authority's Engineer shall either conduct or observe, monitor and review the Tests conducted by the Contractor, as the case may be, and review the results of the Tests to determine compliance of the Project Road or a Section thereof, with Specifications and Standards and if it is reasonably anticipated or determined by the Authority's Engineer during the course of any Test that the performance of the Project Road or Section or any part thereof, does not meet the Specifications and Standards, it shall have the right to suspend or delay such Test and require the Contractor to remedy and rectify the Defect or deficiencies. Upon completion of each Test, the Authority's Engineer shall provide to the Contractor and the Authority copies of all Test data including detailed Test results. For the avoidance of doubt, it is expressly agreed that the Authority's Engineer may require the Contractor to carry out or cause to be carried out additional Tests, in accordance with Good Industry Practice, for determining the compliance of the Project Road or Section thereof with the Specifications and Standards.

12.2 Completion Certificate

(i) Upon completion of all Works forming part of the Project Road, and the Authority's Engineer determining the Tests to be successful and after the receipt of notarized true copies of the certificate(s) of insurance, copies of insurance policies and premium payment receipts in respect of the insurance defined in Article 20 and Schedule P of this Agreement, it shall, at the request of the Contractor forthwith issue to the Contractor and the Authority a certificate substantially in the form set forth in Schedule-L (the "Completion Certificate").

(ii) Upon receiving the Completion Certificate, the Contractor shall remove its equipment, materials, debris and temporary works from the Site within a period of 30 (thirty) days thereof, failing which the Authority may remove or cause to be removed, such equipment, materials, debris and temporary works and recover from the Contractor

an amount equal to 120% (one hundred and twenty per cent) of the actual cost of removal incurred by the Authority.

(iii) Without prejudice to the obligations of the Contractor specified in Articles 14 and 17, the property and ownership of all the completed Works forming part of the Project Road shall vest in the Authority.

12.3 Rescheduling of Tests

If the Authority's Engineer certifies to the Authority and the Contractor that it is unable to issue the Completion Certificate, as the case may be, because of events or circumstances on account of which the Tests could not be held or had to be suspended, the Contractor shall be entitled to re-schedule the Tests and hold the same as soon as reasonably practicable.

Article 13

Change of Scope

13.1 Change of Scope

(i) The Authority may, notwithstanding anything to the contrary contained in this Agreement, require the Contractor to make modifications/ alterations to the Works ("**Change of Scope**") within a period of six months counted from the Appointed Date. Upon the Authority making its intention known to the Contractor for the specific Change of Scope, be it positive or negative, the Contractor shall submit his proposal for the said Change of Scope involving additional cost or reduction in cost. Any such Change of Scope shall be made and valued in accordance with the provisions of this Article 13.

(ii) Provided that any such Change of Scope, excluding major structures (e.g. Major Bridge/ ROB/ RUB/ Flyover/ elevated road of more than 50 m length) may be required and agreed to be executed between the parties beyond the period of six months of the Appointed Date but before expiry of 50% of the original Scheduled Construction Period of the Project Road, subject to the condition that it shall not entail any claims (e.g. Extension of Time/ Prolongation related claims), against the Authority.

(iii) The Change of Scope shall mean the following:

(a) change in specifications of any item of Works;

(b) omission of any work from the Scope of the Project except under Clause 8.3 (iii); provided that, subject to Clause 13.5, the Authority shall not omit any Work under this Clause in order to get it executed by any other authority; and / or

(c) any additional Work, Plant, Materials or services which are not included in the Scope of the Project, including any associated Tests on completion of construction.

13.2 Procedure for Change of Scope

(i) In the event of the Authority determining that a Change of Scope is necessary, it may direct the Authority's Engineer to issue to the Contractor a notice specifying in reasonable detail the Works and services contemplated thereunder (the "**Change of Scope Notice**"). The Contractor shall submit a detailed proposal as per Clause 13.2 (iii) within 15 days from the receipt of Change of Scope Notice.

(ii) If the Contractor determines, not later than 90 days from the Appointed Date, that a Change of Scope to the Works is required, it shall prepare a proposal with relevant details as per Clause 13.2 (iii) at its own cost and shall submit to the Authority to consider such Change of Scope (the "**Change of Scope Request**").

(iii) Upon receipt of a Change of Scope Notice, the Contractor shall, with due diligence, provide to the Authority and the Authority's Engineer such information as is necessary, together with detailed proposal in support of:

(a) the impact, if any, which the Change of Scope is likely to have on the Project Completion Schedule if the works or services are required to be carried out during the Construction Period; and

(b) the options for implementing the proposed Change of Scope and the effect, if any, each such option would have on the costs and time thereof, including the following details:

i. break-up of the quantities, unit rates and cost for different items of work; and

ii. proposed design for the Change of Scope;

iii. proposed modifications, if any, to the Project Completion Schedule of the Project Road.

For the avoidance of doubt, the Parties expressly agree that, subject to the provisions of Clause 13.4 (ii), the Contract Price shall be increased or decreased, as the case may be, on account of any such Change of Scope.

(iv) The parties agree that costs and time for implementation of the proposed Change of Scope shall be determined as per the following:

(a) For works where Schedule of Rates (SOR) of Bangalore or Bengaluru circle of State's Public Works Department are applicable at the Base Date are available, the same shall be applicable for determination of costs. In case of non-availability of Schedule of Rates at the Base Date, the available Schedule of Rates shall be applied by updating the same based on WPI. In case the Contract Price is lower/ higher than the Estimated Project Cost as per RFP, then the SOR rates shall be reduced/ increased in the same proportion accordingly.

(b) For item of Works not included in Schedule of Rates as mentioned in sub-para (a) of Clause 13.2 (iv) above, the cost of same shall be derived on the basis of MORTH Standard Data Book-2019 and the Authority's Engineer shall determine the prevailing market rates and discount the same considering WPI to achieve the prevailing rate at the Base Date, and for any item in respect of which MORTH Standard Data Book does not provide the requisite details, the Authority's Engineer shall determine the rate in accordance with Good Industry Practice.

For the avoidance of doubt, in case the cost as determined by the Contractor and the Authority reveals a difference of more than 10% (ten per cent), the cost as determined by the Authority shall be considered as final and binding on the Contractor.

(c) The design charges shall be considered only for new works or items (i.e. the Works or items not similar to the works or items in the original scope) @ 1% (one per cent) of cost of such new works or items.

(d) The costs of existing works or items, which are being changed/ omitted shall also be valued as per above procedure and only net cost shall be considered.

(e) The reasonable time for completion of works to be taken under Change of Scope shall be determined by the Authority's Engineer on the basis of Good Industry Practice and if such time exceeds the Scheduled Completion Date, the issue of Completion Certificate shall not be affected or delayed on account of construction of Change of Scope items/ works remaining incomplete on the date of Tests.

(v) Upon consideration of the detailed proposal submitted by the Contractor under the Clause 13.2 (iii), the Authority, within 15 (fifteen) days of receipt of such proposal, may in its sole discretion either accept such Change of Scope with modifications, if any, and initiate proceedings thereof in accordance with this Article 13 or reject the proposal and inform the Contractor of its decision and shall issue an order (the **"Change of Scope Order"**) requiring the Contractor to proceed with the performance thereof.

For the avoidance of doubt, the Parties agree that the Contractor shall not undertake any Change of Scope without the express consent of the Authority, save and except any works necessary for meeting any Emergency, that too with verbal approval of Authority which shall be confirmed in writing in next 3 (three) days. In the event that the Parties are unable to agree, the Authority may:

(a) issue a Change of Scope Order requiring the Contractor to proceed with the performance thereof at the rates and conditions approved by the Authority till the matter is resolved in accordance with Article 26;

or

(b) proceed in accordance with Clause 13.5.

(vi) The provisions of this Agreement, insofar as they relate to Works and Tests, shall apply *mutatis mutandis* to the Works undertaken by the Contractor under this Article 13.

13.3 Payment for Change of Scope

Payment for Change of Scope shall be made in accordance with the payment schedule specified in the Change of Scope Order.

13.4 Restrictions on Change of Scope

(i) No Change of Scope shall be executed unless the Authority has issued the Change of Scope Order save and except any Works necessary for meeting any Emergency.

(ii) The total value of all Change of Scope Orders shall not exceed 10% (ten per cent) of the Contract Price.

(iii) Notwithstanding anything to the contrary in this Article 13, if any change is necessitated because of any default of the Contractor in the performance of its obligations under this Agreement, the same shall not be deemed to be Change of Scope, and shall not result in any adjustment of the Contract Price or the Project Completion Schedule.

13.5 Power of the Authority to undertake Works

(i) In the event the Parties are unable to agree to the proposed Change of Scope Orders in accordance with Clause 13.2, the Authority may, after giving notice to the Contractor and considering its reply thereto, award such Works or services to any person or agency on the basis of open competitive bidding. It is also agreed that the Contractor shall provide assistance and cooperation to the person or agency who undertakes the works or services hereunder. The Contractor shall not be responsible for rectification of any Defects, but the Contractor shall carry out maintenance of such works after completion of Defect Liability Period of work by other person or agency during the remaining period of this agreement without any extra payment.

(ii) The Works undertaken in accordance with this Clause 13.5 shall conform to the Specifications and Standards and shall be carried out in a manner that minimises the disruption in operation of the Project Road. The provisions of this Agreement, insofar as they relate to Works and Tests, shall apply *mutatis mutandis* to the Works carried out under this Clause 13.5.

Article 14

Maintenance

14.1 Maintenance obligations of the Contractor

(i) The Contractor shall maintain the Project Road for a period of ~~[5 (five) /~~ *10 (ten)* years, corresponding to the Defects Liability Period, commencing from the date of the Completion Certificate (the "**Maintenance Period**"). For the performance of its Maintenance obligations, the Contractor shall be paid:

(a) For flexible pavement with 5 years Maintenance Period including structures: no maintenance charges shall be paid for the first year; 0.50%of the Contract Price each for the second, third and fourth year; and 1% of the Contract Price for the fifth year

(b) For rigid pavement with 10 years Maintenance Period including structures: 0.25% of the Contract Price each for the first, second and third year, 0.5% of the Contract Price each for fourth, fifth, sixth and seventh year, and 0.75% of the Contract Price each for eighth, ninth and tenth year.

(c) For flexible perpetual pavement with 10 years maintenance period including structures: no maintenance charges shall be paid for the first year; 0.5% of the Contract Price each for the second, third and fourth year; 0.75% of the Contract Price each for the subsequent years till laying of the renewal layer or end of maintenance period, whichever is earlier. The requirement for the renewal layer shall be worked out based on the survey and investigation of the existing pavement and the cost of such renewal works shall be made separately to the Contractor based on the principles defined under clause 13.2(iii). After laying of the renewal layer, the Contractor shall be paid @ 0.5% of the original Contract Price each for the remaining years till the end of maintenance period.

(d) For stand-alone Bridge/ Tunnel works: the contractor shall be paid @ 0.25% of the Contract Price each for the first five years and @ 0.50% of the Contract Price each for the remaining period of five years. This work shall be considered as standalone tunnel work for this purpose.

Above amount for the performance of Contractors' Maintenance obligations shall be, inclusive of all taxes. The amount payable for maintenance shall be adjusted to reflect any increase or decrease arising out of variation in WPI to be determined in accordance with the provisions of Clause 19.12. It is further agreed that the Contract Price hereunder shall be reckoned with reference to the amount specified in Clause 19.1 (i), which shall be adjusted to the extent of Change of Scope and the works withdrawn under the provisions of Clause 8.3 (iii), but shall not include any price adjustments in pursuance of Clause 19.10.

(ii) During the Maintenance Period, the Authority shall provide to the Contractor access to the Site for Maintenance in accordance with this Agreement. The obligations of the Contractor hereunder shall include:

(a) permitting safe, smooth and uninterrupted flow of traffic on the Project Road;

(b) undertaking routine maintenance including prompt repairs of potholes, cracks, joints, drains, embankments, structures, pavement markings, lighting, road signs and other traffic control devices. For the avoidance of doubt, the electricity charges for operation of electrical infrastructure installed along the project length, except the infrastructure being used by the Contractor for its own use, shall be borne by the Authority;

(c) undertaking repairs to structures;

(d) informing the Authority of any unauthorised use of the Project Road;

(e) informing the Authority of any encroachments on the Project Road; and

(f) operation and maintenance of all communication, patrolling, and administrative systems necessary for the efficient maintenance of the Project Road in accordance with the provisions of this Agreement.

(iii) In respect of any Defect or deficiency not specified in Schedule-E, the Contractor shall, at its own cost, undertake repair or rectification in accordance with Good Industry Practice, save and except to the extent that such Defect or deficiency shall have arisen on account of any wilful default or neglect of the Authority or a Force Majeure Event.

(iv) The Contractor shall remove promptly from the Project Road any waste materials (including hazardous materials and waste water), rubbish and other debris (including, without limitation, accident debris) and keep the Project Road in a clean, tidy and orderly condition, and in conformity with the Applicable Laws, Applicable Permits and Good Industry Practice.

14.2 Maintenance Requirements

The Contractor shall ensure and procure that at all times during the Maintenance Period; the Project Road conforms to the maintenance requirements set forth in Schedule-E (the "**Maintenance Requirements**").

14.3 Maintenance Programme

(i) The Contractor shall prepare a monthly maintenance programme (the "**Maintenance Programme**") in consultation with the Authority's Engineer and submit the same to the Authority's Engineer not later than 10 (ten) days prior to the commencement of the month in which the Maintenance is to be carried out. For this purpose a joint monthly inspection by the Contractor and the Authority's Engineer shall be undertaken. The Maintenance Programme shall contain the following:

(a) The condition of the road in the format prescribed by the Authority's Engineer;

(b) the proposed maintenance Works; and

(c) deployment of resources for maintenance Works.

14.4 Safety, vehicle breakdowns and accidents

(i) The Contractor shall ensure safe conditions for the Users, and in the event of unsafe conditions, lane closures, diversions, vehicle breakdowns and accidents, it shall follow the relevant operating procedures for removal of obstruction and debris without delay. Such procedures shall conform to the provisions of this Agreement, Applicable Laws, Applicable Permits and Good Industry Practice.

(ii) The Contractor shall maintain and operate a round-the-clock vehicle rescue post with 1 (one) mobile crane having the capacity to lift a truck with a Gross Vehicle Weight of 30,000 (thirty thousand) kilograms; and such post shall be located at [****]. The Contractor shall promptly remove any damaged vehicles and debris from the Project Road to enable safe movement of traffic and shall report all accidents to the police forthwith.

14.5 Lane closure

(i) The Contractor shall not close any lane of the Project Road for undertaking maintenance works except with the prior written approval of the Authority's Engineer. Such approval shall be sought by the Contractor through a written request to be made at least 10 (ten) days before the proposed closure of lane and shall be accompanied by particulars thereof. Within 5 (five) business days of receiving such request, the Authority's Engineer shall grant permission with such modifications as it may deem necessary and a copy of such permission shall be sent to the Authority.

(ii) Upon receiving the permission pursuant to Clause 14.5 (i), the Contractor shall be entitled to close the designated lane for the period specified therein, and for all lane closures extending a continuous period of 48 (forty-eight) hours, the Contractor shall, in the event of any delay in re-opening such lane, for every stretch of 250 (two hundred and fifty) metres, or part thereof, pay Damages to the Authority calculated at the rate of 0.1% (zero point one per cent) of the monthly maintenance payment for each day of delay until the lane has been re-opened for traffic. In the event of any delay in re-opening such lanes or in the event of emergency decommissioning and closure to traffic of the whole or any part of the Project Road due to failure of the Contractor, the Contractor shall pay damages to the Authority at double the above rate, without prejudice the rights of the Authority under this Agreement including Termination thereof.

14.6 Reduction of payment for non-performance of Maintenance obligations

(i) In the event that the Contractor fails to repair or rectify any Defect or deficiency set forth in Schedule-E within the period specified therein, it shall be deemed as failure of

performance of Maintenance obligations by the Contractor and the Authority shall be entitled to effect reduction in monthly lump sum payment for maintenance in accordance with Clause 19.7 and Schedule-M, without prejudice to the rights of the Authority under this Agreement, including Termination thereof.

(ii) If the nature and extent of any Defect justifies more time for its repair or rectification than the time specified in Schedule-E, the Contractor shall be entitled to additional time in conformity with Good Industry Practice. Such additional time shall be determined by the Authority's Engineer and conveyed to the Contractor and the Authority with reasons thereof.

14.7 Authority's right to take remedial measures

In the event the Contractor does not maintain and/or repair the Project Road or any part thereof in conformity with the Maintenance Requirements, the Maintenance Manual or the Maintenance Programme, as the case may be, and fails to commence remedial works within 15 (fifteen) days of receipt of the Maintenance Inspection Report under Clause 15.2 or a notice in this behalf from the Authority or the Authority's Engineer, as the case may be, the Authority shall, without prejudice to its rights under this Agreement including Termination thereof, be entitled to undertake such remedial measures at the cost of the Contractor, and to recover its cost from the Contractor. In addition to recovery of the aforesaid cost, a sum equal to 20% (twenty per cent) of such cost shall be paid by the Contractor to the Authority as Damages.

14.8 Restoration of loss or damage to Project Road

Save and except as otherwise expressly provided in this Agreement, in the event that the Project Road or any part thereof suffers any loss or damage during the Maintenance from any cause attributable to the Contractor, the Contractor shall, at its cost and expense, rectify and remedy such loss or damage forthwith so that the Project Road conforms to the provisions of this Agreement.

14.9 Overriding powers of the Authority

(i) If in the reasonable opinion of the Authority, the Contractor is in material breach of its obligations under this Agreement and, in particular, the Maintenance Requirements, and such breach is causing or likely to cause material hardship or danger to the Users and pedestrians, the Authority may, without prejudice to any of its rights under this Agreement including Termination thereof, by notice require the Contractor to take reasonable measures immediately for rectifying or removing such hardship or danger, as the case may be.

(ii) In the event that the Contractor, upon notice under Clause 14.9 (i), fails to rectify or remove any hardship or danger within a reasonable period, the Authority may exercise overriding powers under this Clause 14.9 (ii) and take over the performance of any or all the obligations of the Contractor to the extent deemed necessary by it for rectifying or removing such hardship or danger; provided that the exercise of such overriding powers by the Authority shall be of no greater scope and of no longer

duration than is reasonably required hereunder; provided further that any costs and expenses incurred by the Authority in discharge of its obligations hereunder shall be recovered by the Authority from the Contractor, and the Authority shall be entitled to deduct any such costs and expenses incurred from the payments due to the Contractor under Clause 19.7 for the performance of its Maintenance obligations.

(iii) In the event of a national emergency, civil commotion or any other circumstances specified in Clause 21.3, the Authority may take over the performance of any or all the obligations of the Contractor to the extent deemed necessary by it, and exercise such control over the Project Road or give such directions to the Contractor as may be deemed necessary; provided that the exercise of such overriding powers by the Authority shall be of no greater scope and of no longer duration than is reasonably required in the circumstances which caused the exercise of such overriding power by the Authority. For the avoidance of doubt, it is agreed that the consequences of such action shall be dealt in accordance with the provisions of Article 21. It is also agreed that the Contractor shall comply with such instructions as the Authority may issue in pursuance of the provisions of this Clause 14.9 (iii), and shall provide assistance and cooperation to the Authority, on a best effort basis, for performance of its obligations hereunder.

14.10 Taking over Certificate

The Maintenance Requirements set forth in Schedule-E having been duly carried out, Maintenance Period as set forth in Clause 14.1 (i) having been expired and Authority's Engineer determining the Tests on Completion of Maintenance to be successful in accordance with Schedule-Q, the Authority will issue Taking Over Certificate to the Contractor substantially in the format set forth in Schedule-R.

Article 15

Supervision and Monitoring during Maintenance

15.1 Inspection by the Contractor

(i) The Authority's Engineer shall undertake regular inspections to evaluate continuously the compliance with the Maintenance Requirements.

(ii) The Contractor shall carry out a detailed pre-monsoon inspection of all bridges, culverts and drainage system in accordance with the guidelines contained in IRC: SP35. Report of this inspection together with details of proposed maintenance works as required shall be conveyed to the Authority's Engineer forthwith. The Contractor shall complete the proposed maintenance works before the onset of the monsoon and send a compliance report to the Authority's Engineer. Post monsoon inspection shall be undertaken by the Contractor and the inspection report together with details of any damages observed and proposed action to remedy the same shall be conveyed to the Authority's Engineer forthwith.

15.2 Inspection and payments

(i) The Authority's Engineer may inspect the Project Road at any time, but at least once every month, to ensure compliance with the Maintenance Requirements. It shall make a report of such inspection (**"Maintenance Inspection Report"**) stating in reasonable detail the Defects or deficiencies, if any, with particular reference to the Maintenance Requirements, the Maintenance Manual, and the Maintenance Programme, and send a copy thereof to the Authority and the Contractor within 10 (ten) days of such inspection.

(ii) After the Contractor submits to the Authority's Engineer the Monthly Maintenance Statement for the Project Road pursuant to Clause 19.6, the Authority's Engineer shall carry out an inspection within 10 (ten) days to certify the amount payable to the Contractor. The Authority's Engineer shall inform the Contractor of its intention to carry out the inspection at least 3 (three) business days in advance of such inspection. The Contractor shall assist the Authority's Engineer in verifying compliance with the Maintenance Requirements.

(iii) For each case of non-compliance of Maintenance Requirements as specified in the inspection report of the Authority's Engineer, the Authority's Engineer shall calculate the amount of reduction in payment in accordance with the formula specified in Schedule-M.

(iv) Any deduction made on account of non-compliance will not be paid subsequently even after establishing the compliance thereof. Such deductions will continue to be made every month until the compliance is procured.

15.3 Tests

For determining that the Project Road conforms to the Maintenance Requirements, the Authority's Engineer shall require the Contractor to carry out, or cause to be carried out, Tests specified by it in accordance with Good Industry Practice. The Contractor shall, with due diligence, carry out or cause to be carried out all such Tests in accordance with the instructions of the Authority's Engineer and furnish the results of such Tests forthwith to the Authority' Engineer.

At any time during Maintenance Period, the Authority may appoint an external technical auditor to conduct an audit of the quality of the Works. The Auditor in the presence of the representatives of the Contractor and the Authority's Engineer shall carry out the Tests and/ or collect samples for testing in the laboratory. The timing, the testing equipment and the sample size of this audit shall be as decided by the Authority. The findings of the audit, to the extent accepted by the Authority, shall be notified to the Contractor and the Authority's Engineer for taking remedial measures. After completion of the remedial measures by the Contractor, the auditor shall undertake a closure audit and this process will continue till the remedial measures have brought the maintenance works into compliance with the Specifications and Standards. The Contractor shall provide all assistance as may be required by the auditor in the conduct of its audit hereunder. Notwithstanding anything contained in this Clause 15.3, the external technical audit shall not affect any obligations of the Contractor or the Authority's Engineer under this Agreement.

15.4 Reports of unusual occurrence

The Contractor shall, during the Maintenance Period, prior to the close of each day, send to the Authority and the Authority's Engineer, by facsimile or e- mail, a report stating accidents and unusual occurrences on the Project Road relating to the safety and security of the Users and Project Road. A monthly summary of such reports shall also be sent within 3 (three) business days of the closing of month. For the purposes of this Clause 15.4, accidents and unusual occurrences on the Project Road shall include:

(a) accident, death or severe injury to any person;

(b) damaged or dislodged fixed equipment;

(c) flooding of Project Road; and

(d) any other unusual occurrence.

Article 16

Traffic Regulation

16.1 Traffic regulation by the Contractor

(i) The Contractor shall take all the required measures and make arrangements for the safety of Users during the Construction and Maintenance of the Project Road or a Section thereof in accordance with the provisions of MORTH Specifications. It shall provide, erect and maintain all such barricades, signs, markings, flags, and lights as may be required by Good Industry Practice for the safety of the traffic passing through the Section under construction or maintenance.

(ii) All works shall be carried out in a manner creating least interference to traffic passing through the Project Road or a Section thereof. In sections where construction or maintenance Works on the carriageway are taken up, the Contractor shall ensure that proper passage is provided for the traffic. Where it is not possible or safe to allow traffic on part width of the carriageway, a temporary diversion of proper specifications shall be constructed by the Contractor at its own cost. 'ROBOTS' may be used for diversion and control of traffic during Construction. The Contractor shall take prior approval of the Authority's Engineer for any proposed arrangement for traffic regulation during Construction and Maintenance, which approval shall not be unreasonably withheld.

Article 17

Defects Liability

17.1 Defects Liability Period

(i) The Contractor shall be responsible for all the Defects and deficiencies, except usual wear and tear in the Project Road or any Section thereof, till the expiry of a period of commencing from the date of Completion Certificate (the "**Defects Liability Period**") as specified below:

(a) 5 (five) years from the date of completion in case of a road being constructed with flexible pavement;

(b) 10 (ten) years from the date of completion in case of road being constructed with rigid pavement;

(c) 10 (ten) years from the date of completion in case of road being constructed with flexible pavement using perpetual design;

(a) 10 (ten) years from the date of completion in case of all stand-alone structures, e.g. Major Bridges/ and Tunnels. This work shall be considered as standalone tunnel work for this purpose.

(d) 10 (ten) years from the date of completion for the stretches where new technology/ material has been/ is proposed to be used.

(e) 3 (three) years from the date of completion for stretches requiring renewal of Bituminous Concrete (BC) layer through either using hot-in-place recycling of the entire BC layer or providing a fresh layer of BC with 40mm thickness.

(f) 3 (three) years from the date of completion for stretches requiring improvement to riding quality, in cases other than those mentioned in para (f) above, through laying a layer of BM/DBM and BC.

The Defects Liability Period shall commence from the date of the Completion Certificate. For the avoidance of any doubt, any repairs or restoration because of usual wear or tear in the Project Road or any Section thereof shall form a part of the Maintenance obligations of the Contractor as specified in Article 14.

17.2 Remedying Defects

Save and except as provided in Clause 14.1 (iii), the Contractor shall repair or rectify all Defects and deficiencies observed by the Authority or Authority's Engineer during the Defects Liability Period within a period of 15 (fifteen) days from the date of notice issued by the Authority or Authority's Engineer in this behalf, or within such reasonable period as may be determined by the Authority or Authority's Engineer at the request of the Contractor, in accordance with Good Industry Practice.

17.3 Cost of remedying Defects

Any repair or rectification undertaken in accordance with the provisions of Clause 17.2, including any additional testing, shall be carried out by the Contractor at its own risk and cost, to the extent that such rectification or repair is attributable to:

(a) the design of the Project;

(b) Plant, Materials or workmanship not being in accordance with this Agreement and the Specifications and Standards;

(c) improper maintenance during construction of the Project Road by the Contractor; and/ or

(d) failure by the Contractor to comply with any other obligation under this Agreement.

17.4 Contractor's failure to rectify Defects

If the Contractor fails to repair or rectify such Defect or deficiency within the period specified in Clause 17.2, the Authority shall be entitled to get the same repaired, rectified or remedied at the Contractor's cost to make the Project Road conform to the Specifications and Standards and the provisions of this Agreement. All costs consequent thereon shall, after due consultation with the Authority and the Contractor, be determined by the Authority's Engineer. The cost so determined and an amount equal to 20% (twenty percent) of the cost as Damages shall be recoverable by the Authority from the Contractor and may be deducted by the Authority from any monies due to the Contractor.

17.5 Extension of Defects Liability Period

The Defects Liability Period shall be deemed to be extended till the identified Defects under Clause 17.2 have been remedied or rectified.

Article 18

Authority's Engineer

18.1 Appointment of the Authority's Engineer

(i) The Authority shall appoint a firm of Consulting Engineers or a Project Monitoring Committee (PMC) substantially in accordance with the selection criteria set forth in Schedule-N, to be the engineer under this Agreement (the "**Authority's Engineer**"). In unavoidable circumstances, Authority may appoint an officer to act as Authority's Engineer until appointment of a Consulting Engineering firm/ Supervision Consultant/ PMC.

(ii) The officer in-charge of the Authority is responsible for the overall supervision and monitoring of the execution of project as the representative of the owner of the project. The Authority's Engineer is appointed to assist the Authority for carrying out the functions as detailed under clause 18.2. As such, an officer of the Authority is vested with all such powers and responsibilities as are enjoined upon the Authority's Engineer and is fully competent to issue any instructions for proper monitoring and supervision of the project, either by himself or through the Authority's Engineer. Instructions issued by the concerned officer of the Authority shall have the same effect as that of the Authority's Engineer in terms of this Agreement. Wherever such concerned officer issues any instructions or notice to the Contractor, he shall endorse a copy thereof to the Authority's Engineer.

(iii) The Authority's Engineer should be appointed within 10 days from the date of this Agreement or before declaration of Appointed Date, whichever is earlier. The Authority shall notify the appointment or replacement of the Authority's Engineer to the Contractor.

(iv) The staff of the Authority's Engineer shall include suitably qualified engineers and other professionals who are competent to assist the Authority's Engineer to carry out its duties.

18.2 Duties and authority of the Authority's Engineer

(i) The Authority's Engineer shall perform the duties and exercise the authority in accordance with the provisions of this Agreement and substantially in accordance with the terms of reference ("**Terms of Reference" or "TOR")** set forth in Annexure-I of Schedule N, but subject to obtaining prior written approval of the Authority before determining:

(a) any Time Extension;

(b) any additional cost to be paid by the Authority to the Contractor;

(c) the Termination Payment;

(d) issuance of Completion Certificate; or

(e) any other matter which is not specified in (a), (b), (c) or (d) above and which creates financial liability on either Party.

(ii) No decision or communication of the Authority's Engineer shall be effective or valid unless it is accompanied by an attested true copy of the approval of the Authority for and in respect of any matter specified in Clause 18.2 (i).

(iii) The Authority's Engineer shall submit regular periodic reports, at least once every month, to the Authority in respect of its duties and functions under this Agreement. Such reports shall be submitted by the Authority's Engineer within 10 (ten) days of the beginning of every month. For the avoidance of doubt, the Authority's Engineer shall include in its report, compliance of the recommendations of the Safety Consultant.

(iv) The Authority's Engineer shall ensure that NSV surveys be conducted at the following intervals:

(a) Before start of the work,

(b) Before issue of provisional/ final completion certificate,

(c) Every 6 months after completion of work

The NSV reports shall be uploaded on Online Portal (if any) as well in hard copies

(v) The Authority's Engineer in consultation with the Authority shall update online Portal of the Authority (if any) and also ensure to submit Monthly and Quarterly Progress Report along with Strip Chart. Such updations shall be done on the last date of every month/ quarter and if required, on a weekly basis as advised by the Authority. Monthly invoices towards services of the Authority's Engineer shall not be admitted for payment in case of non-compliance of the above.

18.3 Delegation by the Authority's Engineer

(i) The Authority's Engineer may, by order in writing, delegate any of his duties and responsibilities to suitably qualified and experienced personnel who are accountable to Authority's Engineer, or may revoke any such delegation, under intimation to the Authority and the Contractor. Provided, however, that the Authority's Engineer shall be responsible and liable for all actions and omissions of such personnel.

(ii) Any failure of the Authority's Engineer to disapprove any work, Plant or Materials shall not constitute approval, and shall, therefore, not prejudice the right of the Authority to reject the work, Plant or Materials, which is not in accordance with the provisions of this Agreement and the Specifications and Standards.

(iii) Notwithstanding anything stated in Clause 18.3 (i) above, the Authority's Engineer shall not delegate the authority to refer any matter for the Authority's prior approval wherever required in accordance with the provisions of Clause 18.2.

18.4 Instructions of the Authority's Engineer

(i) The Authority's Engineer may issue instructions for remedying any Defect(s) to the Contractor. The Contractor shall take such instructions from the Authority's Engineer, or from an assistant to whom appropriate authority has been delegated under Clause 18.3.

(ii) The instructions issued by the Authority's Engineer shall be in writing. However, if the Authority's Engineer issues any oral instructions to the Contractor, it shall confirm the oral instructions in writing within 2 (two) working days of issuing them.

(iii) In case the Contractor does not receive the confirmation of the oral instructions within the time specified in Clause 18.4 (ii), the Contractor shall seek the written confirmation of the oral instructions from the Authority's Engineer. The Contractor shall obtain acknowledgement from the Authority's Engineer of the communication seeking written confirmation. In case of failure of the Authority's Engineer or its delegated assistant to reply to the Contractor within 2 (two) days of the receipt of the communication from the Contractor, the Contractor may not carry out the instructions.

(iv) In case of any dispute on any of the instructions issued by the delegated assistant, the Contractor may refer the dispute to the Authority's Engineer, who shall then confirm, reverse or vary the instructions within 3 (three) business days of the dispute being referred.

18.5 Determination by the Authority's Engineer

(i) The Authority's Engineer shall consult with each Party in an endeavour to reach agreement wherever this Agreement provides for the determination of any matter by the Authority's Engineer. If such agreement is not achieved, the Authority's Engineer shall make a fair determination in accordance with this Agreement having due regard to all relevant circumstances. The Authority's Engineer shall give notice to both the Parties of each agreement or determination, with supporting particulars.

(ii) Each Party shall give effect to each agreement or determination made by the Authority's Engineer in accordance with the provisions of this Agreement. Provided, however, that if any Party disputes any instruction, decision, direction or determination of the Authority's Engineer, the Dispute shall be resolved in accordance with the Dispute Resolution Procedure.

18.6 Remuneration of the Authority's Engineer

The remuneration, costs and expenses of the Authority's Engineer shall be paid by the Authority.

18.7 Termination of the Authority's Engineer

(i) The Authority may, in its discretion, replace the Authority's Engineer at any time. However, the Authority shall ensure that alternative arrangements for appointment of another Authority's Engineer or designation of its own officer as the Authority Engineer for the intervening period are made simultaneously.

(ii) If the Contractor has reasons to believe that the Authority's Engineer is not discharging its duties and functions in accordance with the provisions of this Agreement, it may make a written representation to the Authority and seek termination of the appointment of the Authority's Engineer. Upon receipt of such representation, the Authority shall hold a tripartite meeting with the Contractor and the Authority's Engineer and make best efforts for an amicable resolution of the representation. In the event that the appointment of the Authority's Engineer is terminated hereunder, the Authority shall appoint forthwith another Authority's Engineer in accordance with Clause 18.1 and 18.7 (i).

Part IV

Financial Covenants

Article 19

Payments

19.1 Contract Price

(i) The Authority shall make payments to the Contractor for the Works on the basis of the lump sum price accepted by the Authority in consideration of the obligations specified in this Agreement for an amount of INR …… (INR……) (the "**Contract Price**"), which shall be subject to adjustments in accordance with the provisions of this Agreement. For the avoidance of doubt, the Parties expressly agree that the Contract Price shall not include the cost of Maintenance, which shall be paid separately in accordance with the provisions of Clause 19.7. The Parties further agree that save and except as provided in this Agreement, the Contract Price shall be valid and effective until issue of Completion Certificate.

(ii) The Contract Price includes all duties, taxes (excluding GST, which shall be payable at the applicable rates), royalty, cess, charges, and fees that may be levied in accordance with the laws and regulations in force as on the Base Date on the Contractor's equipment, Plant, Materials and supplies acquired for the purpose of this Agreement and on the services performed under this Agreement. Nothing in this Agreement shall relieve the Contractor from its responsibility to pay any tax including any tax that may be levied in India on profits made by it in respect of this Agreement. The Contract Price also includes the cost of shifting of obstructing Utilities (including all centages as applicable by the utility owning department except supervision charges) as given in clause 9.2 and Schedule B.

(iii) The Contract Price shall not be adjusted for any change in costs stated in Clause 19.1 (ii) above, except as stated in Clauses 19.10 and 19.17.

(iv) The Contract Price shall not be adjusted to take account of any unforeseen difficulties or costs, unless otherwise provided for in this Agreement.

(v) Unless otherwise stated in this Agreement, the Contract Price covers all the Contractor's obligations for the Works under this Agreement and all things necessary for the Construction and the remedying of any Defects in the Project Road.

(vi) All payments under this Agreement shall be made in Indian Rupees.

19.2 Advance Payment

(i) The Authority shall make an interest-bearing advance payment (the "**Advance Payment**") @ "**Bank Rate + 3%**", equal to 10 % (ten percent) of the Contract Price, exclusively for mobilisation expenses. The Advance Payment for mobilisation expenses shall be made in two instalments each equal to 5% (five percent) of the Contract Price. The second 5% (five percent) mobilization advance would be released after submission of utilization certificate by the Contractor for the first 5% (five per cent) advance already released earlier.

(ii) In addition to above, the Authority shall make an additional interest-bearing Advance Payment against newly purchased key Construction equipment required for the works as per agreed Construction programme and brought to the site, if so requested by the Contractor subject to the same terms and conditions specified for Advance Payment for mobilisation expenses in this Agreement. The maximum of such advance shall be 5% (five per cent) of the Contract Price against Bank Guarantee. This advance shall be further subject to the condition that:

(a) such new equipment are considered by the Authority's Engineer to be necessary for the works and

(b) these new equipment should be procured in the name of Contractor and is verified by Authority's Engineer to have been brought to site.

The Advance Payment for mobilization expenses and for acquisition of key new Construction equipment would be deemed as interest bearing advance at the applicable interest rate (@"Bank rate + 3%"), to be compounded annually on a reducing balance basis. The interest would be recovered along with the recovery of mobilization Advance Payment as per provision laid down for the mobilization advance recovery.

(iii) The Contractor may apply to the Authority for the first instalment of the Advance Payment at any time after the Appointed Date, along with an irrevocable and unconditional guarantee from a Bank for an amount equivalent to 110% (one hundred and ten per cent) of such instalment, substantially in the form provided at Annex-III of Schedule-G, to remain effective till the complete and full repayment thereof.

(iv) At any time, after 60 (sixty) days from the Appointed Date, the Contractor may apply to the Authority for the second instalment of the Advance Payment along with an irrevocable and unconditional guarantee from a Bank for an amount equivalent to 110% (one hundred and ten per cent) of such instalment, substantially in the form provided at Annex-III of Schedule-G, to remain effective till the complete and full repayment thereof.

The Contractor has the option of splitting the Bank Guarantee against Advance Payment for mobilization expenses into parts, each not less than 2.75% (two point seven five per cent) of the Contract Price. Each part of the guarantee shall remain effective till full repayment of such part advance corresponding to this bank guarantee. Such part of Bank Guarantee shall be returned to the Contractor on recovery under the Agreement of the full amount of such part guarantee within 30 (thirty) days of the said recovery.

(v) The Advance Payment shall be paid by the Authority to the Contractor within 15 (fifteen) days of the receipt of its respective requests in accordance with the provisions of this Clause 19.2.

(vi) The Advance Payment shall be repaid through percentage deductions from the stage payments determined by the Authority's Engineer in accordance with Clause 19.5, as follows:

(a) deductions shall commence in the first Stage Payment Statement;

(b) deductions shall be made at the rate of 15% (fifteen percent) of each Stage Payment Statement until such time as the advance payment has been repaid; provided that the advance payment shall be completely repaid prior to the time when 80% (eighty percent) of the Schedule Construction Period is over;

(c) if total certified stage payments (excluding the Advance Payment and deductions and repayments of retention) does not exceed 20% (twenty percent) of the Contract Price within [50% of the Scheduled Construction Period] from the Appointed Date then the Advance Payment including interest shall be recovered by encashment of the Bank Guarantee for the Advance Payment.

(vii) If the Advance Payment has not been fully repaid prior to Termination under Clause 21.7 or Article 23, as the case may be, the whole of the balance then outstanding shall immediately become due and payable by the Contractor to the Authority. Without prejudice to the provisions of Clause 19.2 (vi), in the event of Termination for Contractor Default, the Advance Payment shall be deemed to carry interest @ "**Bank Rate+5%**" per annum from the date of Advance Payment to the date of recovery by encashment of the Bank Guarantee for the Advance Payment. For the avoidance of doubt, the aforesaid interest shall be payable on the unrecovered balance.

19.3 Procedure for estimating the payment for the Works

(i) The Authority shall make interim payments to the Contractor as certified by the Authority's Engineer on completion of a stage, in a length, number or area as specified and valued in accordance with the proportion of the Contract Price assigned to each item and its stage in Schedule-H.

(ii) The Contractor shall base its claim for interim payment for the stages completed till the end of the month for which the payment is claimed, valued in accordance with Clause 19.3 (i), supported with necessary particulars and documents in accordance with this Agreement.

(iii) Any reduction in the Contract Price arising out of Change of Scope or the works withdrawn under Clause 8.3 shall not affect the amounts payable for the items or stage payments thereof which are not affected by such Change of Scope or withdrawal. For avoidance of doubt and by way of illustration, the Parties agree that if the amount assigned to Major Bridges is reduced from Rs. 100 crore to Rs. 80 crore owing to Change of Scope or withdrawal of work, the reduction in payment shall be restricted to relevant payments for Major Bridges only and the payment due in respect of all other stage payments under the item Major Bridges shall not be affected in any manner. The Parties further agree that the adjustments arising out of the aforesaid modifications shall be carried out in a manner that the impact of such modifications is restricted to the said Change of Scope or withdrawal, as the case may be, and does not alter the payments due for and in respect of items or stage payments which do not form part of such Change of Scope or withdrawal.

19.4 Stage Payment Statement for Works

The Contractor shall submit a statement (the **"Stage Payment Statement")**, in 3 (three) copies, by the 7th (seventh) day of the month to the Authority's Engineer in the form set forth in Schedule-O, showing the amount calculated in accordance with Clause 19.3 to which the Contractor considers himself entitled for completed stage(s) of the Works. The Stage Payment Statement shall be accompanied with the progress reports and any other supporting documents. The Contractor shall not submit any claim for payment of incomplete stages of work.

19.5 Stage Payment for Works

(i) Within 10 (ten) days of receipt of the Stage Payment Statement from the Contractor pursuant to Clause 19.4, the Authority's Engineer shall broadly determine the amount due to the Contractor and recommend the release of 90 (ninety) percent of the amount so determined as part payment against the Stage Payment Statement, pending issue of the Interim Payment Certificate by the Authority's Engineer. Within 10 (ten) days of the receipt of recommendation of the Authority's Engineer, the Authority shall make electronic payment directly to the Contractor's bank account.

(ii) Within 15 (fifteen) days of the receipt of the Stage Payment Statement referred to in Clause 19.4, the Authority's Engineer shall determine and shall deliver to the Authority and the Contractor an IPC certifying the amount due and payable to the Contractor, after adjusting the payments already released to the Contractor against the said statement. For the avoidance of doubt, the Parties agree that the IPC shall specify all the amounts that have been deducted from the Stage Payment Statement and the reasons therefor.

(iii) In cases where there is a difference of opinion as to the value of any stage, the Authority's Engineer's view shall prevail and interim payments shall be made to the Contractor on this basis; provided that the foregoing shall be without prejudice to the Contractor's right to raise a Dispute.

(iv) The Authority's Engineer may, for reasons to be recorded, withhold from payment:

(a) the estimated value of work or obligation that the Contractor has failed to perform in accordance with this Agreement and the Authority's Engineer had notified the Contractor; and

(b) the estimated cost of rectification of work done being not in accordance with this Agreement.

(v) Payment by the Authority shall not be deemed to indicate the Authority's acceptance, approval, consent or satisfaction with the work done.

19.6 Monthly Maintenance Statement of the Project Road

(i) The Contractor shall submit to the Authority's Engineer a monthly maintenance statement ("**Monthly Maintenance Statement")** in 3 (three) copies by the 7th

(seventh) day of each month in the format set forth in Schedule-O for the Maintenance of the Project Road during the previous month.

(ii) The monthly lump sum amount payable for Maintenance shall be 1/12th (one- twelfth) of the annual cost of Maintenance as specified in Clause 14.1 (i).

19.7 Payment for Maintenance of the Project Road

(i) Within 15 (fifteen) days of receipt of the Monthly Maintenance Statement from the Contractor pursuant to Clause 19.6, the Authority's Engineer shall verify the Contractor's monthly maintenance statement and certify the amount to be paid to the Contractor taking into account:

(a) Compliance with the Maintenance Requirements; and

(b) reduction for non-compliance with the Maintenance Requirement in accordance with Clause 19.7 (ii).

The Authority's Engineer shall deliver to the Authority an IPC approving or amending the monthly maintenance statement to reflect the amount due to the Contractor in accordance with this Agreement.

(ii) Maintenance shall be measured in units of one kilometre each; provided, however, that payment thereof shall be made in fixed monthly amounts in accordance with this Agreement. If the Maintenance Requirements set forth in Schedule-E are not met, reduction in payments shall be made in accordance with the provisions of Schedule-M. The reductions for non-compliance with the Maintenance Requirements shall be applied on the basis of monthly inspections by the Authority's Engineer.

(iii) The deduction made on account of non-compliance with the Maintenance Requirements shall not be subsequently considered for payment after the compliance is achieved by repair or rectification.

(iv) The Authority shall pay to the Contractor every quarter any amount due under any IPC under this Clause 19.7. The payment shall be made no later than 30 (thirty) days from the date of submission of the last IPC for the relevant quarter.

19.8 Payment of Damages

(i) The Contractor may claim Damages due and payable to it in accordance with the provisions of this Agreement.

(ii) The Authority's Engineer shall issue the IPC within 15 (fifteen) days of the receipt of the claim under Clause 19.8 (i), after making adjustments in accordance with the provisions of this Agreement. The Authority shall pay to the Contractor the amount due under any IPC within a period of 30 (thirty) days from the date of the submission of the claim under this Clause 19.8. In the event of the failure of the Authority to make payment to the Contractor within the specified time, the Authority shall be liable to

pay to the Contractor interest thereon and the provisions of Clause 19.9 shall apply *mutatis mutandis* thereto.

19.9 Time of payment and interest

(i) The Authority shall pay to the Contractor any amount due under any payment certificate issued by the Authority's Engineer in accordance with the provisions of this Article 19, or in accordance with any other clause of this Agreement as follows:

(a) payment shall be made no later than 30 (thirty) days from the date of submission of the Stage Payment Statement by the Contractor to the Authority's Engineer for certification in accordance with the provisions of Clause 19.4 for an IPC; provided that, in the event the IPC is not issued by the Authority's Engineer within the aforesaid period of 30 (thirty) days, the Authority shall pay the amount shown in the Contractor's Stage Payment Statement and any discrepancy therein shall be added to, or deducted from, the next payment certificate issued to the Contractor; and

(b) payment shall be made no later than 30 (thirty) days from the date of submission of the Final Payment Certificate for Works along with the discharge submitted to the Authority's Engineer in accordance with the provisions of Clause 19.15 for certification.

(ii) In the event of the failure of the Authority to make payment to the Contractor within the time period stated in this Clause 19.9, the Authority shall be liable to pay to the Contractor interest @ Bank Rate+ 3% per annum, on all sums remaining unpaid from the date on which the same should have been paid, calculated in accordance with the provisions of sub-Clauses (a) and (b) of Clause 19.9 (i) and till the date of actual payment.

19.10 Price adjustment for the Works

(i) The amounts payable to the Contractor for Works shall be adjusted in accordance with the provisions of this Clause 19.10

(ii) Subject to the provisions of Clause 19.10 (iii), the amounts payable to the Contractor for Works, shall be adjusted in the IPC issued by the Authority's Engineer for the increase or decrease in the index cost of inputs for the Works, by the addition or subtraction of the amounts determined by the formulae prescribed in Clause 19.10 (iv).

(iii) To the extent that full compensation for any increase or decrease in costs to the Contractor is not covered by the provisions of this or other Clauses in this Agreement, the costs and prices payable under this Agreement shall be deemed to include the amounts required to cover the contingency of such other increase or decrease of costs and prices.

(iv) The Contract Price shall be adjusted for increase or decrease in rates and price of labour, cement, steel, Plant, machinery and spares, bitumen, fuel and lubricants, and

other material inputs in accordance with the principles, procedures and formulae specified below:

(a) Price adjustment shall be applied on completion of the specified stage of the respective item of work in accordance with Schedule-H;

(b) Adjustment for each item of work/stage shall be made separately;

(c) The following expressions and meanings are assigned to the value of the work done:

RW= Value of work done for the completion of a stage under the following items of Schedule-H:

i. Road works including culverts, widening and repair of culverts

ii. Other works

BR = Value of work done for the completion of a stage under the items Tunnel works and ROB/ RUB, if any (Schedule-H)

(d) Price adjustment for changes in cost shall be paid in accordance with the following formulae:

(i) $$VRW = 0.85RW \times [PL \times \frac{L_1 - L_0}{L_0} - PA \times \frac{A_1 - A_0}{A_0} + PF \times \frac{F_1 - F_0}{F_0} + PB \times \frac{B_1 - B_2}{B_0} - PM \times \frac{M_1 - M_2}{M_2} - PC \times \frac{C_1 - C_0}{C_0} - PS \times \frac{S_1 - S_0}{S_0}]$$

(ii) $$VBR = 0.85BR \times [PL \times \frac{L_1 - L_0}{L_0} + PA \times \frac{A_1 - A_2}{A_0} + PF \times \frac{F_1 - F_0}{F_0} + PM \times \frac{M_1 - M_0}{M_0} + PC \times \frac{C_1 - C_0}{C_0} + PS \times \frac{S_1 - S_0}{S_2}]$$

Where,

VRW = Increase or decrease in the cost of Road works including culverts, widening and repair of culverts/other works during the period under consideration due to changes in the rates for relevant components as stated in sub-paragraph (e).

VBR = Increase or decrease in the cost of Tunnel works and ROB/ RUB during the period under consideration due to changes in the rates for relevant components as stated in sub-paragraph (e).

PB, PC, PL, PM, and PS are the percentages of bitumen, cement, labour, other materials, and steel/components (including strands and cables) respectively for the relevant item as stated in sub-paragraph (e).

PA is the percentage of Plant, machinery and spares component for the relevant item as stated in sub-paragraph (e).

PF is the percentage of fuel and lubricants for the relevant items as stated in sub-paragraph (e).

A_0 = The wholesale price index as published by the Ministry of Commerce & Industry, Government of India (hereinafter called "WPI") for "Manufacture of machinery for mining, quarrying and construction" for the month of the Base Date.

A_I = The WPI for construction machinery for the month three months prior to the month to which the IPC relates.

B_0 = The official retail price of bitumen at refinery nearest to the site on the Base Date.

B_I = The official retail price of bitumen at refinery nearest to the site, on the first day of the month three months prior to the month to which the IPC relates.

C_0 = The WPI for Ordinary Portland Cement for the month of the Base Date.

C_I = The WPI for Ordinary Portland Cement for the month three months prior to the month to which the IPC relates.

F_0 = The official retail price of high speed diesel (HSD) oil at the existing consumer pumps of Indian Oil Corporation ("IOC") in Bangalore on the Base Date.

F_I = The official retail price of HSD at the existing consumer pumps of IOC in Bangalore on the first day of the month three months prior to the month to which the IPC relates.

L_0 = The consumer price index for industrial workers for the Bangalore Circle in the State of Karnataka, published by Labour Bureau, Ministry of Labour, Government of India, (hereinafter called "CPI") for the month of the Base Date.

L_I = The CPI for the Bangalore Circle in the State of Karnataka, published by Labour Bureau, Ministry of Labour, Government of India, (hereinafter called "CPI") for the month three months prior to the month to which the IPC relates.

M_0 = The WPI for all commodities for the month of the Base Date.

M_I = The WPI for all commodities for the month three months prior to the month to which the IPC relates.

S_0 = The WPI for Mild Steel –Long Products for the month of the Base Date.

S_I = The WPI for Mild Steel –Long Products for the month three months prior to the month to which the IPC relates.

(e) The following percentages shall govern the price adjustment of the Contract Price:

Component	Tunnel works and ROB/ RUB				
	Earthwork, Granular work, Drain Work and Other works	Bituminous work	Cement Concrete Pavement	Culverts, minor bridges and other structures including Retaining Wall, Stone Pitching, Protection Work	Tunnel, Major Bridges and Structures including Retaining Wall, Stone Pitching, Protection Work
Labour (PL)	[20%]	Nil	[20%]	[15%]	[15%]
Cement (PC)	[5%]	Nil	[20%]	[15%]	[15%]
Steel (PS)	Nil	Nil	Nil	[15%]	[20%]
Bitumen (PB)	Nil	Nil	Nil	Nil	Nil
Fuel and lubricants (PF)	[10%]	Nil	[10%]	[10%]	[10%]
Other Materials (PM)	[50%]	Nil	[35%]	[30%]	[25%]
Plant, machinery and spares. (PA)	[15%]	Nil	[15%]	[15%]	[15%]
Total	100%	Nil	100%	100%	100%

19.11 Restrictions on price adjustment

Price adjustment shall be due and payable only in respect of the stages of Works for which the Stage Payment Statement has been submitted by the Contractor no later than 30 (thirty) days from the date of the applicable Project Milestone or the Scheduled Completion Date, as the case may be, including any Time Extension granted therefor in accordance with the provisions of this Agreement. For the avoidance of doubt, in the event of submission of any Stage Payment Statement after the period specified herein, price adjustment shall be applicable until the date of the respective Project Milestone or the Scheduled Completion Date, as the case may be.

19.12 Price adjustment for Maintenance of Project Road

Lump sum payment for Maintenance shall be adjusted every quarter for changes in rates and prices of various inputs in accordance with the formula given below:

$$V = P \times \frac{W_i - W_0}{W_0}$$

Where

V= Increase or decrease in the quarterly lump sum payment

P= Quarterly lump sum payment due to the Contractor after adjusting any reduction in

payment for non-compliance of the Maintenance Requirements

W_0= The wholesale price index (all commodities) for the month of the Base Date.

W_I= The wholesale price index (all commodities) for the first day of the quarter under consideration for determining the price adjustment.

19.13 Final Payment Statement

(i) Within 60 (sixty) days after receiving the Completion Certificate under Clause 12.2, the Contractor shall submit to the Authority's Engineer for consideration 6 (six) copies of a Final Payment Statement (the "**Final Payment Statement**") for Works, with supporting documents showing in detail, in the form prescribed by the Authority's Engineer:

(a) the summary of Contractor's Stage Payment claims for Works as submitted in accordance with Clause 19.4;

(b) the amounts received from the Authority against each claim; and

(c) any further sums which the Contractor considers due to it from the Authority.

If the Authority's Engineer disagrees with or cannot verify any part of the Final Payment Statement, the Contractor shall submit such further information as the Authority's Engineer may reasonably require. The Authority's Engineer shall deliver to the Authority:

i. an IPC for those parts of the Final Payment Statement which are not in dispute, along with a list of disputed items which shall then be settled in accordance with the provisions of Article 26; or

ii. a Final Payment Certificate in accordance with Clause 19.15 if there are no disputed items.

(ii) If the Authority's Engineer does not prescribe the form referred to in Clause 19.13 (i) within 15 (fifteen) of the date of issue of the Completion Certificate, the Contractor shall submit the statement in such form as it deems fit.

19.14 Discharge

Upon submission of the Final Payment Statement for Works under Clause 19.13, the Contractor shall give to the Authority, with a copy to the Authority's Engineer, a written discharge confirming that the total of the Final Payment Statement represents full and final settlement of all monies due to the Contractor in respect of this Agreement for all the Works arising out of this Agreement, except for any monies due to either Party on account of any Defect. Provided that such discharge shall become effective only after the payment due has been made in accordance with the Final Payment Certificate issued pursuant to Clause 19.15.

19.15 Final Payment Certificate

(i) Within 30 (thirty) days after receipt of the Final Payment Statement for Works under

Clause 19.13, and the written discharge under Clause 19.14, and there being no disputed items of claim, the Authority's Engineer shall deliver to the Authority, with a copy to the Contractor, a final payment certificate (the "**Final Payment Certificate")** stating the amount which, in the opinion of the Authority's Engineer, is finally due under this Agreement or otherwise. For the avoidance of doubt, before issuing the Final Payment Certificate, the Authority's Engineer shall ascertain from the Authority all amounts previously paid by the Authority and for all sums to which the Authority is entitled, the balance, if any, due from the Authority to the Contractor or from the Contractor to the Authority, as the case may be.

(ii) The Authority shall, in accordance with the provisions of Clause 19.9, pay to the Contractor the amount which is stated as being finally due in the Final Payment Certificate.

19.16 Final payment statement for Maintenance

(i) Within 30 (thirty) days after completion of the Maintenance Period, the Contractor shall submit to the Authority's Engineer 6 (six) copies of the final payment statement for Maintenance of the Project Road, with supporting documents showing the details set forth below in the form prescribed by the Authority's Engineer:

(a) the total amount claimed in accordance with clause 19.7 (i) and

(b) any sums which the Contractor considers to be due to it, with supporting documents.

(ii) The Authority's Engineer shall certify final payment within 30 (thirty) days of the receipt of the final payment statement of Maintenance under Clause 19.16 (i), segregating the items of amount payable from the items of amount disallowed. The Authority shall make payment on the basis of the final payment authorised by the Authority's Engineer within a period of 30 (thirty) days of the receipt of the Final Payment Statement from the Authority's Engineer.

(iii) If the Authority's Engineer does not prescribe the form within 15 (fifteen) days of the date of issue of the Completion Certificate, the Contractor shall submit the statement in such form as it deems fit.

19.17 Change in law

(i) If as a result of Change in Law, the Contractor suffers any additional costs in the execution of the Works or in relation to the performance of its other obligations under this Agreement, the Contractor shall, within 15 (fifteen) days from the date it becomes reasonably aware of such addition in cost, notify the Authority with a copy to the Authority's Engineer of such additional cost due to Change in Law.

(ii) If as a result of Change in Law, the Contractor benefits from any reduction in costs for the execution of this Agreement or in accordance with the provisions of this Agreement, either Party shall, within 15 (fifteen) days from the date it becomes reasonably aware of such reduction in cost, notify the other Party with a copy to the Authority's Engineer of such reduction in cost due to Change in Law.

(iii) The Authority's Engineer shall, within 15 (fifteen) days from the date of receipt of the notice from the Contractor or the Authority, determine any addition or reduction to the Contract Price, as the case may be, due to the Change in Law.

19.18 Correction of Interim Payment Certificates

The Authority's Engineer may by an Interim Payment Certificate make any correction or modification in any previous Interim Payment Certificate issued by the Authority's Engineer.

19.19 Authority's claims

If the Authority considers itself to be entitled to any payment from the Contractor under any Clause of this Agreement, it shall give notice and particulars to the Contractor 20 (twenty) days before making the recovery from any amount due to the Contractor, and shall take into consideration the representation, if any, made by the Contractor in this behalf, before making such recovery.

19.20 Bonus for early completion

In the event that the Project Completion Date occurs prior to the Scheduled Completion Date, the Contractor shall be entitled to receive a payment of bonus equivalent to 0.03% (zero point zero three per cent) of the Contract Price for each day by which the Project Completion Date precedes the Scheduled Completion Date, but subject to a maximum of 5% (five per cent) of the Contract Price. Provided, however, that the payment of bonus, if any, shall be made only after the issue of the Completion Certificate. For the avoidance of the doubt, the Parties agree that for the purpose of determining the bonus payable hereunder, the works shall always be deemed to be as specified in this Contract Agreement but excluding the works deemed to be deleted from the scope of work under clause 8.3 of this Contract Agreement and the Contract Price shall always be deemed to be the amount specified in Clause 19.1 (i) after excluding the Contract Price of the Works deemed to be deleted from the Scope of Work under clause 8.3 of this Contract Agreement, and shall exclude any revision thereof for any reason. The Parties also agree that bonus shall be payable only if each work for which Time Extension has been granted is completed within respective Extended Time.

Article 20

Insurance

20.1 Insurance for Works and Maintenance

(i) The Contractor shall effect and maintain at its own cost the insurances specified in Schedule-P and as per the requirements under the Applicable Laws.

(ii) Subject to the provisions of Clause 21.6, the Authority and the Contractor shall, in accordance with its obligations as provided for in this Agreement, be liable to bear the cost of any loss or damage that does not fall within the scope of this Article 20 or cannot be recovered from the insurers.

(iii) Subject to the exceptions specified in Clause 20.1 (iv) below, the Contractor shall, save and except as provided for in this Agreement, fully indemnify, hold harmless and defend the Authority from and against any and all losses, damages, costs, charges and/or claims with respect to:

(a) the death of or injury to any person; or

(b) the loss of or damage to any property (other than the Works);

that may arise out of or in consequence of any breach by the Contractor of this Agreement during the execution of the Works or the remedying of any Defects therein.

(iv) Notwithstanding anything stated above in Clause 20.1 (iii), the Authority shall fully indemnify the Contractor from and against any and all losses, damages, costs, charges, proceedings and/or claims arising out of or with respect to:

(a) the use or occupation of land or any part thereof by the Authority;

(b) the right of the Authority to execute the Works, or any part thereof, on, over, under, in or through any land;

(c) the damage to property which is the unavoidable result of the execution and completion of the Works, or the remedying of any Defects therein, in accordance with this Agreement; and

(d) the death of or injury to persons or loss of or damage to property resulting from any act or neglect of the Authority, its agents, servants or other contractors, not being employed by the Contractor.

Provided that, in the event of any injury or damage as a result of the contributory negligence of the Contractor, the Authority shall be liable to indemnify the Contractor from and against any and all losses, damages, costs, charges, proceedings and/or claims to the extent as may be proportionately determined to be the liability of the Authority, its servants or agents or other contractors not associated with the Contractor in such injury or damage.

(v) Without prejudice to the obligations of the Parties as specified under Clauses 20.1 (iii) and 20.1 (iv), the Contractor shall maintain or effect such third party insurances as may be required under the Applicable Laws.

(vi) The Contractor shall provide to the Authority, within 30 days of the Appointed Date, evidence of professional liability insurance maintained by its Design Director and/or consultants to cover the risk of professional negligence in the design of Works. The professional liability coverage shall be for a sum of not less than [3% (three per cent)] of the Contract Price and shall be maintained until the end of the Defects Liability Period.

20.2 Notice to the Authority

No later than 15 (fifteen) days after the date of this Agreement, the Contractor shall by notice furnish to the Authority, in reasonable detail, information in respect of the insurances that it proposes to effect and maintain in accordance with this Article 20. Within 15 (fifteen) days of receipt of such notice, the Authority may require the Contractor to effect and maintain such other insurances as may be necessary pursuant hereto, and in the event of any difference or disagreement relating to any such insurance, the Dispute Resolution Procedure shall apply.

20.3 Evidence of Insurance Cover

(i) All insurances obtained by the Contractor in accordance with this Article 20 shall be maintained with insurers on terms consistent with Good Industry Practice. Within 10 (ten) days from the Appointed Date, the Contractor shall furnish to the Authority notarised true copies of the certificate(s) of insurance, copies of insurance policies and premia payment receipts in respect of such insurance, and no such insurance shall be cancelled, modified, or allowed to expire or lapse until the expiration of at least 45 (forty-five) days after notice of such proposed cancellation, modification or non-renewal has been delivered by the Contractor to the Authority. The Contractor shall act in accordance with the directions of the Authority. Provided that the Contractor shall produce to the Authority the insurance policies in force and the receipts for payment of the current premia.

(ii) The Contractor shall ensure the adequacy of the insurances at all times in accordance with the provisions of this Agreement.

20.4 Remedy for failure to insure

If the Contractor shall fail to effect and keep in force all insurances for which it is responsible pursuant hereto, the Authority shall have the option to either keep in force any such insurances, and pay such premia and recover the costs thereof from the Contractor, or in the event of computation of a Termination Payment, treat an amount equal to the Insurance Cover as deemed to have been received by the Contractor.

20.5 Waiver of subrogation

All insurance policies in respect of the insurance obtained by the Contractor pursuant to this Article 20 shall include a waiver of any and all rights of subrogation or recovery of the insurers thereunder against, inter alia, the Authority, and its assigns, successors, undertakings and their subsidiaries, Affiliates, employees, insurers and underwriters, and of any right of the insurers to any set-off or counterclaim or any other deduction, whether by attachment or otherwise, in respect of any liability of any such person insured under any such policy or in any way connected with any loss, liability or obligation covered by such policies of insurance.

20.6 Contractor's waiver

The Contractor hereby further releases, assigns and waives any and all rights of subrogation or recovery against, inter alia, the Authority and its assigns, undertakings and their subsidiaries, Affiliates, employees, successors, insurers and underwriters, which the Contractor may otherwise have or acquire in or from or in any way connected with any loss, liability or obligation covered by policies of insurance maintained or required to be maintained by the Contractor pursuant to this Agreement (other than third party liability insurance policies) or because of deductible clauses in or inadequacy of limits of any such policies of insurance.

20.7 Cross liabilities

Any such insurance maintained or effected in pursuance of this Article 20 shall include a cross liability clause such that the insurance shall apply to the Contractor and to the Authority as separately insured.

20.8 Accident or injury to workmen

Notwithstanding anything stated in this Agreement, it is hereby expressly agreed between the Parties that the Authority shall not be liable for or in respect of any damages or compensation payable to any workman or other person in the employment of the Contractor or Sub-contractor, save and except as for death or injury resulting from any act, omission or wilful default of the Authority, its agents or servants. The Contractor shall indemnify and keep indemnified the Authority from and against all such claims, proceedings, damages, costs, charges, and expenses whatsoever in respect of the above save and except for those acts, omissions or wilful defaults for which the Authority shall be liable.

20.9 Insurance against accident to workmen

The Contractor shall effect and maintain during the Agreement such insurances as may be required to insure the Contractor's personnel and any other persons employed by it on the Project Road from and against any liability incurred in pursuance of this Article 20. Provided that for the purposes of this Clause 20.9, the Contractor's personnel/any person employed by the Contractor shall include the Sub- contractor and its personnel. It is further provided that, in respect of any persons

employed by any Sub-contractor, the Contractor's obligations to insure as aforesaid under this Clause 20.9 shall be discharged if the Sub-contractor shall have insured against any liability in respect of such persons in such manner that the Authority is indemnified under the policy. The Contractor shall require such Sub-contractor to produce before the Authority, when required, such policy of insurance and the receipt for payment of the current premium within 10 (ten) days of such demand being made by the Authority.

20.10 Application of insurance proceeds

The proceeds from all insurance claims, except for life and injury, shall be applied for any necessary repair, reconstruction, reinstatement, replacement, improvement, delivery or installation of the Project Road and the provisions of this Agreement in respect of construction of works shall apply *mutatis mutandis* to the works undertaken out of the proceeds of insurance.

20.11 Compliance with policy conditions

Each Party hereby expressly agrees to fully indemnify the other Party from and against all losses and claims arising from its failure to comply with conditions imposed by the insurance policies effected in accordance with this Agreement.

20.12 General Requirements of Insurance Policies

The Contractor must:

(a) immediately deposit copies of the policies or certificates of any insurance which it is required to effect under the Contract, together with receiptsfor the premiums;

(b) effect all insurances for which the Contractor is responsible with an insurer approved by the Authority;

(c) make no material changes to the terms of any insurance without the Authority's approval;

(d) in all respects comply with any conditions stipulated in the insurance policies which the Contractor is required to effect under the Agreement or which the Authority has effected in relation to the Facility and notified to the Contractor; and shall provide all assistance to the Authority in the application for, and finalization of, such comprehensive insurance package;

(e) regardless of the extent of settlement of claims by the underwriters or the time taken for settlement of claims, the Contractor shall make good any loss, or damage at its own cost promptly;

(f) provide all assistance to the Authority in the application for, and finalization of, such comprehensive insurance package;

(g) pay the Contractor's share of the insurance premiums for insurance premiums allocated under such comprehensive insurance package policy to

the insurances directly to the insurance provider promptly on demand. In case the Contractor fails to make such payment in time, the Authority may elect to pay the Contractor's share and adjust it against amounts payable to the Contractor under this Agreement;

(h) in the case of occurrence of any event leading to an insurance claim, promptly follow the procedures specified by the insurance provider, and provide full cooperation and access to the insurance provider or its representative, to settle the claim expeditiously;

(i) require all the Sub-Contractors providing equipment and materials or services to the Contractor or the Authority to obtain, maintain and keep in force during the time in which they are involved in the performance of the Works hereunder insurance coverage consistent with the Contractor's insurance obligations hereunder and the Contractor shall also be responsible for fulfillment of this requirement; and

(j) the required insurance coverage and the Contractor's obligations-referred to shall in no way affect or limit the Contractor's liability with respect to its performance of the Works. Nothing in this Section shall limit or relieve the Contractor of its liabilities and obligations under this Agreement.

Part V

Force Majeure and Termination

Article 21

Force Majeure

21.1 Force Majeure

As used in this Agreement, the expression "**Force Majeure**" or "**Force Majeure Event**" shall mean occurrence in India of any or all of Non-Political Event, Indirect Political Event and Political Event, as defined in Clauses 21.2, 21.3 and 21.4 respectively, if it affects the performance by the Party claiming the benefit of Force Majeure (the "**Affected Party**") of its obligations under this Agreement and which act or event (i) is beyond the reasonable control of the Affected Party, and (ii) the Affected Party could not have prevented or overcome by exercise of due diligence and following Good Industry Practice, and (iii) has Material Adverse Effect on the Affected Party.

21.2 Non-Political Event

A Non-Political Event shall mean one or more of the following acts or events:

(a) act of God, epidemic, extremely adverse weather conditions, lightning, earthquake, landslide, cyclone, flood, volcanic eruption, chemical or radioactive contamination or ionising radiation, fire or explosion (to the extent of contamination or radiation or fire or explosion originating from a source external to the Site);

(b) strikes or boycotts (other than those involving the Contractor, Sub- contractors or their respective employees/ representatives, or attributable to any act or omission of any of them) interrupting supplies and services to the Project Road for a continuous period of 24 (twenty-four) hours and an aggregate period exceeding 10 (ten) days in an Accounting Year, and not being an Indirect Political Event set forth in Clause 21.3;

(c) any failure or delay of a Sub-contractor but only to the extent caused by another Non-Political Event;

(d) any judgement or order of any court of competent jurisdiction or statutory authority made against the Contractor in any proceedings for reasons other than (i) failure of the Contractor to comply with any Applicable Law or Applicable Permit, or (ii) on account of breach of any Applicable Law or Applicable Permit or of any contract, or (iii) enforcement of this Agreement, or (iv) exercise of any of its rights under this Agreement by the Authority;

(e) the discovery of geological conditions, toxic contamination or archaeological remains on the Site that could not reasonably have been expected to be discovered through a site inspection; or

(f) any event or circumstances of a nature analogous to any of the foregoing.

21.3 Indirect Political Event

An Indirect Political Event shall mean one or more of the following acts or events:

(a) an act of war (whether declared or undeclared), invasion, armed conflict or act of foreign enemy, blockade, embargo, riot, insurrection, terrorist or military action, civil commotion or politically motivated sabotage;

(b) industry-wide or State-wide strikes or industrial action for a continuous period of 24 (twenty-four) hours and exceeding an aggregate period of 10 (ten) days in an Accounting Year;

(c) any civil commotion, boycott or political agitation which prevents construction of the Project Road by the Contractor for an aggregate period exceeding 10 (ten) days in an Accounting Year;

(d) any failure or delay of a Sub-contractor to the extent caused by any Indirect Political Event;

(e) any Indirect Political Event that causes a Non-Political Event; or

(f) any event or circumstances of a nature analogous to any of the foregoing.

21.4 Political Event

A Political Event shall mean one or more of the following acts or events by or on account of any Government Instrumentality:

(a) Change in Law, only if consequences thereof cannot be dealt with under and in accordance with the provisions of Clause 19.17;

(b) compulsory acquisition in national interest or expropriation of any Project Assets or rights of the Contractor or of the Sub-Contractors;

(c) unlawful or unauthorised or without jurisdiction revocation of, or refusal to renew or grant without valid cause, any clearance, license, permit, authorisation, no objection certificate, consent, approval or exemption required by the Contractor or any of the Sub-contractors to perform their respective obligations under this Agreement; provided that such delay, modification, denial, refusal or revocation did not result from the Contractor's or any Sub-contractor's inability or failure to comply with any condition relating to grant, maintenance or renewal of such clearance, license, authorisation, no objection certificate, exemption, consent, approval or permit;

(d) any failure or delay of a Sub-contractor but only to the extent caused by another Political Event; or

(e) any event or circumstances of a nature analogous to any of the foregoing.

21.5 Duty to report Force Majeure Event

(i) Upon occurrence of a Force Majeure Event, the Affected Party shall by notice report such occurrence to the other Party forthwith. Any notice pursuant hereto shall include full particulars of:

(a) the nature and extent of each Force Majeure Event which is the subject of any claim for relief under this Article 21 with evidence in support thereof;

(b) the estimated duration and the effect or probable effect which such Force Majeure Event is having or will have on the Affected Party's performance of its obligations under this Agreement;

(c) the measures which the Affected Party is taking or proposes to take for alleviating the impact of such Force Majeure Event; and

(d) any other information relevant to the Affected Party's claim.

(ii) The Affected Party shall not be entitled to any relief for or in respect of a Force Majeure Event unless it shall have notified the other Party of the occurrence of the Force Majeure Event as soon as reasonably practicable, and in any event no later than 10 (ten) days after the Affected Party knew, or ought reasonably to have known, of its occurrence, and shall have given particulars of the probable material effect that the Force Majeure Event is likely to have on the performance of its obligations under this Agreement.

(iii) For so long as the Affected Party continues to claim to be materially affected by such Force Majeure Event, it shall provide the other Party with regular (and not less than weekly) reports containing information as required by Clause 21.5 (i), and such other information as the other Party may reasonably request the Affected Party to provide.

21.6 Effect of Force Majeure Event on the Agreement

(i) Upon the occurrence of any Force Majeure after the Appointed Date, the costs incurred and attributable to such event and directly relating to this Agreement (the "**Force Majeure costs**") shall be allocated and paid as follows:

(a) upon occurrence of a Non-Political Event, the Parties shall bear their respective Force Majeure costs and neither Party shall be required to pay to the other Party any costs thereof;

(b) upon occurrence of an Indirect Political Event, all Force Majeure costs attributable to such Indirect Political Event, and not exceeding the Insurance Cover for such Indirect Political Event, shall be borne by the Contractor, and to the extent Force Majeure costs exceed such Insurance Cover, one half of such excess amount shall be reimbursed by the Authority to the Contractor for the Force Majeure events; and

(c) upon occurrence of a Political Event, all Force Majeure costs attributable to such Political Event shall be reimbursed by the Authority to the Contractor.

(d) For the avoidance of doubt, Force Majeure costs may include costs directly attributable to the Force Majeure Event, but shall not include debt repayment obligations, if any, of the Contractor.

(ii) Save and except as expressly provided in this Article 21, neither Party shall be liable in any manner whatsoever to the other Party in respect of any loss, damage, cost,

expense, claims, demands and proceedings relating to or arising out of occurrence or existence of any Force Majeure Event or exercise of any right pursuant hereto.

(iii) Upon the occurrence of any Force Majeure Event during the Construction Period, the Project Completion Schedule for and in respect of the affected Works shall be extended on a day for day basis for such period as performance of the Contractor's obligations is affected on account of the Force Majeure Event or its subsisting effects.

21.7 Termination Notice for Force Majeure Event

(i) If a Force Majeure Event subsists for a period of 60 (sixty) days or more within a continuous period of 120 (one hundred and twenty) days, either Party may in its discretion terminate this Agreement by issuing a Termination Notice to the other Party without being liable in any manner whatsoever, save as provided in this Article 21, and upon issue of such Termination Notice, this Agreement shall, notwithstanding anything to the contrary contained herein, stand terminated forthwith; provided that before issuing such Termination Notice, the Party intending to issue the Termination Notice shall inform the other Party of such intention and grant 15 (fifteen) days' time to make a representation, and may after the expiry of such 15 (fifteen) days period, whether or not it is in receipt of such representation, in its sole discretion issue the Termination Notice.

21.8 Termination Payment for Force Majeure Event

(i) In the event of this Agreement being terminated on account of a Non-Political Event, the Termination Payment shall be an amount equal to the sum payable under Clause 23.5.

Provided that in the event Termination occurs during the Maintenance Period, the Authority's Engineer shall only determine the value of Works associated with Maintenance.

(ii) If Termination is on account of an Indirect Political Event, the Termination Payment shall include:

(a) any sums due and payable under Clause 23.5; and

(b) the reasonable cost, as determined by the Authority's Engineer, of the Plant and Materials procured by the Contractor and transferred to the Authority for use in Construction or Maintenance, only if such Plant and Materials are in conformity with the Specifications and Standards;

Provided that in the event Termination occurs during the Maintenance Period, the Authority's Engineer shall only determine the value of Works associated with Maintenance.

(iii) If Termination is on account of a Political Event, the Authority shall make a Termination Payment to the Contractor in an amount that would be payable under Clause 23.6 (ii) as if it were an Authority Default.

21.9 Dispute resolution

In the event that the Parties are unable to agree in good faith about the occurrence or existence of a Force Majeure Event, such Dispute shall be finally settled in accordance with the Dispute Resolution Procedure; provided that the burden of proof as to the occurrence or existence of such Force Majeure Event shall be upon the Party claiming relief and/ or excuse on account of such Force Majeure Event.

21.10 Excuse from performance of obligations

If the Affected Party is rendered wholly or partially unable to perform its obligations under this Agreement because of a Force Majeure Event, it shall be excused from performance of such of its obligations to the extent it is unable to perform on account of such Force Majeure Event; provided that:

(a) the suspension of performance shall be of no greater scope and of no longer duration than is reasonably required by the Force Majeure Event;

(b) the Affected Party shall make all reasonable efforts to mitigate or limit damage to the other Party arising out of or as a result of the existence or occurrence of such Force Majeure Event and to cure the same with due diligence; and

(c) when the Affected Party is able to resume performance of its obligations under this Agreement, it shall give to the other Party notice to that effect and shall promptly resume performance of its obligations hereunder.

Article 22

Suspension of Contractor's Rights

22.1 Suspension upon Contractor Default

Upon occurrence of a Contractor Default, the Authority shall be entitled, without prejudice to its other rights and remedies under this Agreement including its rights of Termination hereunder, to (i) suspend carrying out of the Works or Maintenance or any part thereof, and (ii) carry out such Works or Maintenance itself or authorise any other person to exercise or perform the same on its behalf during such suspension (the "**Suspension**"). Suspension hereunder shall be effective forthwith upon issue of notice by the Authority to the Contractor and may extend up to a period not exceeding 90 (ninety) days from the date of issue of such notice.

22.2 Authority to act on behalf of Contractor

During the period of Suspension hereunder, all rights and liabilities vested in the Contractor in accordance with the provisions of this Agreement shall continue to vest therein and all things done or actions taken, including expenditure incurred by the Authority for discharging the obligations of the Contractor under and in accordance with this Agreement shall be deemed to have been done or taken for and on behalf of the Contractor and the Contractor undertakes to indemnify the Authority for all costs incurred during such period. The Contractor hereby licences and sub-licences respectively, the Authority or any other person authorised by it under Clause 22.1 to use during Suspension, all Intellectual Property belonging to or licensed to the Contractor with respect to the Project Road and its design, engineering, construction and maintenance, and which is used or created by the Contractor in performing its obligations under the Agreement.

22.3 Revocation of Suspension

(i) In the event that the Authority shall have rectified or removed the cause of Suspension within a period not exceeding 60 (sixty) days from the date of Suspension, it shall revoke the Suspension forthwith and restore all rights of the Contractor under this Agreement. For the avoidance of doubt, the Parties expressly agree that the Authority may, in its discretion, revoke the Suspension at any time, whether or not the cause of Suspension has been rectified or removed hereunder.

(ii) Upon the Contractor having cured the Contractor Default within a period not exceeding 60 (sixty) days from the date of Suspension, the Authority shall revoke the Suspension forthwith and restore all rights of the Contractor under this Agreement.

22.4 Termination

(i) At any time during the period of Suspension under this Article 22, the Contractor may by notice require the Authority to revoke the Suspension and issue a Termination

Notice. The Authority shall, within 15 (fifteen) days of receipt of such notice, terminate this Agreement under and in accordance with Article 23.

(ii) Notwithstanding anything to the contrary contained in this Agreement, in the event that Suspension is not revoked within 90 (ninety) days from the date of Suspension hereunder, the Agreement shall, upon expiry of the aforesaid period, be deemed to have been terminated by mutual agreement of the Parties and all the provisions of this Agreement shall apply, *mutatis mutandis*, to such Termination as if a Termination Notice had been issued by the Authority upon occurrence of a Contractor Default.

Article 23

Termination

23.1 Termination for Contractor Default

(i) Save as otherwise provided in this Agreement, in the event that any of the defaults specified below shall have occurred, and the Contractor fails to cure the default within the Cure Period set forth below, or where no Cure Period is specified, then within a Cure Period of 60 (sixty) days, the Contractor shall be deemed to be in default of this Agreement (the "**Contractor Default**"), unless the default has occurred solely as a result of any breach of this Agreement by the Authority or due to Force Majeure. The defaults referred to herein shall include:

(a) the Contractor fails to provide, extend or replenish, as the case may be, the Performance Security in accordance with this Agreement;

(b) after the replenishment or furnishing of fresh Performance Security in accordance with Clause 7.3, the Contractor fails to cure, within a Cure Period of 30 (thirty) days, the Contractor Default for which the whole or part of the Performance Security was appropriated;

(c) the Contractor does not achieve the latest outstanding Project Milestone due in accordance with the provisions of Schedule-J, subject to any Time Extension, and continues to be in default for 45 (forty five) days;

(d) the Contractor abandons or manifests intention to abandon the construction or Maintenance of the Project Road without the prior written consent of the Authority;

(e) the Contractor fails to proceed with the Works in accordance with the provisions of Clause 10.1 or stops Works and/or the Maintenance for 30 (thirty) days without reflecting the same in the current programme and such stoppage has not been authorised by the Authority's Engineer;

(f) the Project Completion Date does not occur within the period specified in Schedule-J for the Scheduled Completion Date, or any extension thereof;

(g) the Contractor fails to rectify any Defect, the non-rectification of which shall have a Material Adverse Effect on the Project, within the time specified in this Agreement or as directed by the Authority's Engineer;

(h) the Contractor subcontracts the Works or any part thereof in violation of this Agreement or assigns any part of the Works or the Maintenance without the prior approval of the Authority;

(i) the Contractor creates any Encumbrance in breach of this Agreement;

(j) an execution levied on any of the assets of the Contractor has caused a Material Adverse Effect;

(k) the Contractor is adjudged bankrupt or insolvent, or if a trustee or receiver is appointed for the Contractor or for the whole or material part of its assets that has a material bearing on the Project;

(l) the Contractor has been, or is in the process of being liquidated, dissolved, wound-up, amalgamated or reconstituted in a manner that would cause, in the reasonable opinion of the Authority, a Material Adverse Effect;

(m) a resolution for winding up or insolvency of the Contractor is passed, or any petition for winding up or insolvency of the Contractor is admitted by a court of competent jurisdiction and a provisional liquidator or receiver or interim resolution professional, as the case may be, is appointed and such order has not been set aside within 90 (ninety) days of the date thereof or the Contractor is ordered to be wound up by court except for the purpose of amalgamation or reconstruction; provided that, as part of such amalgamation or reconstruction, the entire property, assets and undertaking of the Contractor are transferred to the amalgamated or reconstructed entity and that the amalgamated or reconstructed entity has unconditionally assumed the obligations of the Contractor under this Agreement; and provided that:

i. the amalgamated or reconstructed entity has the capability and experience necessary for the performance of its obligations under this Agreement; and

ii. the amalgamated or reconstructed entity has the financial standing to perform its obligations under this Agreement and has a credit worthiness at least as good as that of the Contractor as at the Appointed Date;

(n) any representation or warranty of the Contractor herein contained which is, as of the date hereof, found to be false or the Contractor is at any time hereafter found to be in breach or non-compliance thereof;

(o) the Contractor submits to the Authority any statement, notice or other document, in written or electronic form, which has a material effect on the Authority's rights, obligations or interests and which is false in material particulars;

(p) the Contractor has failed to fulfil any obligation, for whichfailure Termination has been specified in this Agreement; or

(q) the Contractor commits a default in complying with any other provision of this Agreement if such a default causes a Material Adverse Effect on the Project or on the Authority.

(r) gives or offers to give (directly or indirectly) to any person any bribe, gift, gratuity, commission or other thing of value, as an inducement or reward:

i. for doing or forbearing to do any action in relation to the Contract, or

ii. for showing or forbearing to show favour or disfavour to any person in relation to the Contract,

or if any of the Contractor's personnel, agents or subcontractors gives or offers to give (directly or indirectly) to any person any such inducement or reward as is described in this sub-paragraph (s). However, lawful

inducements and rewards to Contractor's Personnel shall not entitle termination.

(ii) Without prejudice to any other rights or remedies which the Authority may have under this Agreement, upon occurrence of a Contractor Default, the Authority shall be entitled to terminate this Agreement by issuing a Termination Notice to the Contractor; provided that before issuing the Termination Notice, the Authority shall by a notice inform the Contractor of its intention to issue such Termination Notice and grant 15 (fifteen) days to the Contractor to make a representation, and may after the expiry of such 15 (fifteen) days, whether or not it is in receipt of such representation, issue the Termination Notice.

(iii) The following shall apply in respect of cure of any of the defaults and/ or breaches of the Agreement:

(a) The Cure Period shall commence from the date of the notice by the Authority to the Contractor asking the latter to cure the breach or default specified in such notice;

(b) The Cure Period provided in the Agreement shall not relieve the Contractor from liability for Damages caused by its breach or default;

(c) The Cure Period shall not in any way be extended by any period of suspension under the Agreement;

(d) If the cure of any breach by the Contractor requires any reasonable action by the Contractor that must be approved by the Authority hereunder the applicable Cure Period (and any liability of the Contractor for damages incurred) shall be extended by the period taken by the Authority to accord its required approval.

(iv) After termination of this Agreement for Contractor Default, the Authority may complete the Works and/or arrange for any other entities to do so. The Authority and these entities may then use any Materials, Plant and equipment, Contractor's documents and other design documents made by or on behalf of the Contractor.

23.2 Termination for Authority Default

(i) In the event that any of the defaults specified below shall have occurred, and the Authority fails to cure such default within a Cure Period of 90 (ninety) days or such longer period as has been expressly provided in this Agreement, the Authority shall be deemed to be in default of this Agreement (the "**Authority Default**") unless the default has occurred as a result of any breach of this Agreement by the Contractor or due to Force Majeure. The defaults referred to herein shall include:

(a) the Authority commits a material default in complying with any of the provisions of this Agreement and such default has a Material Adverse Effect on the Contractor;

(b) the Authority has failed to make payment of any amount due and payable to the Contractor within the period specified in this Agreement;

(c) the Authority has failed to provide, within a period of 180 (one hundred and eighty) days from the Appointed Date, the environmental clearances required for construction of the Project Road;

(d) the Authority becomes bankrupt or insolvent, goes into liquidation, has a receiving or administration order made against him, compounds with its creditors, or carries on business under a receiver, trustee or manager for the benefit of its creditors, or if any act is done or event occurs which (under Applicable Laws) has a similar effect;

(e) the Authority repudiates this Agreement or otherwise takes any action that amounts to or manifests an irrevocable intention not to be bound by this Agreement;

(f) the Authority's Engineer fails to issue the relevant Interim Payment Certificate within 60 (sixty) days after receiving a statement and supporting documents; or

(g) the whole work is suspended by Authority beyond 120 (one hundred twenty) days for any reason which is not attributed to the Contractor.

(ii) Without prejudice to any other right or remedy which the Contractor may have under this Agreement, upon occurrence of an Authority Default, the Contractor shall be entitled to terminate this Agreement by issuing a Termination Notice to the Authority; provided that before issuing the Termination Notice, the Contractor shall by a notice inform the Authority of its intention to issue the Termination Notice and grant 15 (fifteen) days to the Authority to make a representation, and may after the expiry of such 15 (fifteen) days, whether or not it is in receipt of such representation, issue the Termination Notice.

If on the consideration of the Authority's representation or otherwise, the contractor does not issue the Termination Notice on such 15th (fifteenth) day and prefers to continue with the project, it is deemed that the cause of action of the Termination Notice has been condoned by the Contractor and hewould be deemed to have waived any claim and forfeited any right to any other remedy on that count or in relation to such action or omission.

23.3 Termination for Authority's convenience

Notwithstanding anything stated hereinabove, the Authority may terminate this Agreement for convenience. The termination shall take effect 30 (thirty) days from the date of notice provided to the Contractor.

23.4 Requirements after Termination

Upon Termination of this Agreement in accordance with the terms of this Article 23, the Contractor shall comply with and conform to the following:

(a) deliver all relevant records, reports, Intellectual Property and other licences pertaining to the Works, Maintenance, other design documents;

(b) transfer and/or deliver all Applicable Permits to the extentpermissible under Applicable Laws; and

(c) vacate the Site within 15 (fifteen) days.

23.5 Valuation of Unpaid Works

(i) Within a period of 45 (forty-five) days after Termination under Clause 23.1, 23.2 or 23.3, as the case may be, has taken effect, the Authority's Engineer shall proceed in accordance with Clause 18.5 to determine as follows the valuation of unpaid Works (the "**Valuation of Unpaid Works**"):

(a) value of the completed stage of the Works, less payments already made;

(b) reasonable value of the partially completed stages of works as on the date of Termination, only if such works conform with the Specifications and Standards; and

(c) value of Maintenance, if any, for completed months, less payments already made, and shall adjust from the sum thereof (i) any other amounts payable or recoverable, as the case may be, in accordance with the provisions of this Agreement; and (ii) all taxes due to be deducted at source.

(ii) The Valuation of Unpaid Works shall be communicated to the Authority, with a copy to the Contractor, within a period of 30 (thirty) days from the date of Termination.

23.6 Termination Payment

(i) Upon Termination on account of Contractor's Default under Clause 23.1, the Authority shall:

(a) encash and appropriate the Performance Security, Additional Performance Security if any and Retention Money, or in the event the Contractor has failed to replenish or extend the Performance Security and Additional Performance Security if any, claim the amount stipulated in Clause 7.1, as agreed pre-determined compensation to the Authority for any losses, delays and cost of completing the Works and Maintenance, if any;

(b) encash and appropriate the Bank Guarantee, if any, for and in respect of the outstanding Advance Payment and interest thereon; and

(c) pay to the Contractor, by way of Termination Payment, an amount equivalent to the Valuation of Unpaid Works after adjusting any other sums payable or recoverable, as the case may be, in accordance with the provisions of this Agreement.

(ii) Upon Termination on account of an Authority Default under Clause 23.2 or for Authority's convenience under Clause 23.3, the Authority shall:

(a) return the Performance Security, Additional Performance Security and Retention Money forthwith;

(b) encash and appropriate the bank guarantee, if any, for and in respect of the outstanding Advance Payment; and

(c) pay to the Contractor, by way of Termination Payment, an amount equal to:

i. Valuation of Unpaid Works;

ii. the reasonable cost of temporary works, as determined by the Authority's Engineer; and

iii. 10% (ten per cent) of the cost of the Works and Maintenance that are not commenced or not completed,

and shall adjust from the sum thereof (i) any other amounts payable or recoverable, as the case may be, in accordance with the provisions of this Agreement, and (ii) all taxes due to be deducted at source.

(iii) Termination Payment shall become due and payable to the Contractor within 30 (thirty) days of a demand being made by the Contractor to the Authority with the necessary particulars, and in the event of any delay, the Authority shall pay interest at Bank Rate + 3% per annum, on the amount of Termination Payment remaining unpaid; provided that such delay shall not exceed 90 (ninety) days. For the avoidance of doubt, it is expressly agreed that Termination Payment shall constitute full discharge by the Authority of its payment obligations in respect thereof hereunder.

(iv) The Contractor expressly agrees that Termination Payment under this Article 23 shall constitute a full and final settlement of all claims of the Contractor on account of Termination of this Agreement and that it shall not have any further right or claim under any law, treaty, convention, contract or otherwise.

23.7 Other rights and obligations of the Parties

Upon Termination for any reason whatsoever:

(a) property and ownership in all Materials, Plant and Works and the Project Road shall, as between the Contractor and the Authority, vest in the Authority in whole; provided that the foregoing shall be without prejudice to Clause 23.6;

(b) risk of loss or damage to any Materials, Plant or Works and the care and custody thereof shall pass from the Contractor to the Authority; and

(c) the Authority shall be entitled to restrain the Contractor and any person claiming through or under the Agreement from entering upon the Site or any part of the Project, which have not been vested in theAuthority in accordance with the provisions of this Agreement.

23.8 Survival of rights

Notwithstanding anything to the contrary contained in this Agreement any Termination pursuant to the provisions of this Agreement shall be without prejudice to the accrued rights of either Party including its right to claim and recover money damages, insurance proceeds, security deposits, and other rights and remedies,which it may have in law or Agreement. All rights and obligations of either Party under this Agreement, including Termination Payments, shall survive the Termination to the extent such survival is necessary for giving effect to such rights and obligations.

23.9 Foreclosure with mutual consent

(i) Without prejudice to any provision of this Agreement, the Authority and Contractor may foreclose this Agreement by mutual consent in circumstances which does not constitute either party's default without any liability or consequential future liability for either party.

(ii) Should a Party intend to foreclose this Agreement by mutual consent, the intending Party shall issue a notice to the other Party and upon issuance of such notice, the other Party may within 15 days from receipt of such notice either agree to such foreclosure or raise objection(s) to the same by intimating either of the two possible positions to the intending Party in writing.

(iii) In either case of the other Party agreeing to the proposed foreclosure or otherwise, the Parties may negotiate the proposed foreclosure and sign a Supplementary Agreement for foreclosure to the main Contract Agreement within 30 (thirty) days of the date agreeing by both Parties. Foreclosure shall not come into effect unless and otherwise Supplementary Agreement is signed.

(iv) Any attempt or endeavor for foreclosure by mutual agreement shall be without prejudice to the rights and obligations of the Parties herein and the factum of such an attempt or exercise shall not stop either of the Parties from discharging their contractual obligations under this Agreement.

(v) For the avoidance of doubt, it is clarified that such foreclosure will be without prejudice to the Contractor and shall not affect the Contractor in any way if it wishes to bid in future projects of the Authority.

Part VI

Other Provisions

Article 24

Assignment and Charges

24.1 Restrictions on assignment and charges

This Agreement shall not be assigned by the Contractor to any person, save and except with the prior consent in writing of the Authority, which consent the Authority shall be entitled to decline without assigning any reason.

24.2 Hypothecation of Materials or Plant

Notwithstanding the provisions of Clause 24.1, the Contractor may pledge or hypothecate to its lenders, any Materials or Plant prior to their incorporation in the Works. Further, the Contractor may, by written notice to the Authority, assign its right to receive payments under this Agreement either absolutely or by way of charge, to any person providing financing to the Contractor in connection with the performance of the Contractor's obligations under this Agreement. The Contractor acknowledges that any such assignment by the Contractor shall not relieve the Contractor from any obligations, duty or responsibility under this Agreement.

Article 25

Liability and Indemnity

25.1 General indemnity

(i) The Contractor will indemnify, defend, save and hold harmless the Authority and its officers, servants, agents, Government Instrumentalities and Government owned and/or controlled entities/enterprises, (the "**Authority Indemnified Persons**") against any and all suits, proceedings, actions, demands and third party claims for any loss, damage, cost and expense of whatever kind and nature, whether arising out of any breach by the Contractor of any of its obligations under this Agreement or from any negligence under the Agreement, including any errors or deficiencies in the design documents, or tort or on any other ground whatsoever, except to the extent that any such suits, proceedings, actions, demands and claims have arisen due to any negligent act or omission, or breach or default of this Agreement on the part of the Authority Indemnified Persons.

25.2 Indemnity by the Contractor

(i) Without limiting the generality of Clause 25.1, the Contractor shall fully indemnify, hold harmless and defend the Authority and the Authority Indemnified Persons from and against any and all loss and/or damages arising out of or with respect to:

(a) failure of the Contractor to comply with Applicable Laws and Applicable Permits;

(b) payment of taxes required to be made by the Contractor in respect of the income or other taxes of the Sub-contractors, suppliers and representatives; or

(c) non-payment of amounts due because of Materials or services furnished to the Contractor or any of its Sub-contractors which are payable by the Contractor or any of its Sub-contractors.

(ii) Without limiting the generality of the provisions of this Article 25, the Contractor shall fully indemnify, hold harmless and defend the Authority Indemnified Persons from and against any and all suits, proceedings, actions, claims, demands, liabilities and damages which the Authority Indemnified Persons may hereafter suffer, or pay by reason of any demands, claims, suits or proceedings arising out of claims of infringement of any domestic or foreign patent rights, copyrights or other intellectual property, proprietary or confidentiality rights with respect to any materials, information, design or process used by the Contractor or by the Sub-contractors in performing the Contractor's obligations or in any way incorporated in or related to the Project. If in any such suit, action, claim or proceedings, a temporary restraint order or preliminary injunction is granted, the Contractor shall make every reasonable effort, by giving a satisfactory bond or otherwise, to secure the revocation

or suspension of the injunction or restraint order. If, in any such suit, action, claim or proceedings, the Project Road, or any part thereof or comprised therein, is held to constitute an infringement and its use is permanently enjoined, the Contractor shall promptly make every reasonable effort to secure for the Authority a licence, at no cost to the Authority, authorizing continued use of the infringing work. If the Contractor is unable to secure such licence within a reasonable time, the Contractor shall, at its own expense, and without impairing the Specifications and Standards, either replace the affected work, or part, or process thereof with non-infringing work or part or process or modify the same so that it becomes non-infringing.

25.3 Notice and contest of claims

In the event that either Party receives a claim or demand from a third party in respect of which it is entitled to the benefit of an indemnity under this Article 25 (the "**Indemnified Party**") it shall notify the other Party (the "**Indemnifying Party**") within 15 (fifteen) days of receipt of the claim or demand and shall not settle or pay the claim without the prior approval of the Indemnifying Party, which approval shall not be unreasonably withheld or delayed. If the Indemnifying Party wishes to contest or dispute the claim or demand, it may conduct the proceedings in the name of the Indemnified Party, subject to the Indemnified Party being secured against any costs involved, to its reasonable satisfaction.

25.4 Defence of claims

(i) The Indemnified Party shall have the right, but not the obligation, to contest, defend and litigate any claim, action, suit or proceeding by any third party alleged or asserted against such Party in respect of, resulting from, related to or arising out of any matter for which it is entitled to be indemnified hereunder, and reasonable costs and expenses thereof shall be indemnified by the Indemnifying Party. If the Indemnifying Party acknowledges in writing its obligation to indemnify the Indemnified Party in respect of loss to the full extent provided by this Article 25, the Indemnifying Party shall be entitled, at its option, to assume and control the defence of such claim, action, suit or proceeding, liabilities, payments and obligations at its expense and through the counsel of its choice; provided it gives prompt notice of its intention to do so to the Indemnified Party and reimburses the Indemnified Party for the reasonable cost and expenses incurred by the Indemnified Party prior to the assumption by the Indemnifying Party of such defence. The Indemnifying Party shall not be entitled to settle or compromise any claim, demand, action, suit or proceeding without the prior written consent of the Indemnified Party, unless the Indemnifying Party provides such security to the Indemnified Party as shall be reasonably required by the Indemnified Party to secure the loss to be indemnified hereunder to the extent so compromised or settled.

(ii) If the Indemnifying Party has exercised its rights under Clause 25.3, the Indemnified Party shall not be entitled to settle or compromise any claim, action, suit or proceeding without the prior written consent of the Indemnifying Party (which consent shall not be unreasonably withheld or delayed).

(iii) If the Indemnifying Party exercises its rights under Clause 25.3, the Indemnified Party shall nevertheless have the right to employ its own counsel, and such counsel may participate in such action, but the fees and expenses of such counsel shall be at the expense of the Indemnified Party, when and as incurred, unless:

(a) the employment of counsel by such party has been authorised in writing by the Indemnifying Party; or

(b) the Indemnified Party shall have reasonably concluded that there may be a conflict of interest between the Indemnifying Party and the Indemnified Party in the conduct of the defence of such action; or

(c) the Indemnifying Party shall not, in fact, have employed independent counsel reasonably satisfactory to the Indemnified Party, to assume the defence of such action and shall have been so notified by the Indemnified Party; or

(d) the Indemnified Party shall have reasonably concluded and specifically notified the Indemnifying Party either:

i. that there may be specific defences available to it which are different from or additional to those available to the Indemnifying Party; or

ii. that such claim, action, suit or proceeding involves or could have a material adverse effect upon it beyond the scope of this Agreement:

Provided that if Sub-clauses (b), (c) or (d) of this Clause 25.4 (iii) shall be applicable, the counsel for the Indemnified Party shall have the right to direct the defence of such claim, demand, action, suit or proceeding on behalf of the Indemnified Party, and the reasonable fees and disbursements of such counsel shall constitute legal or other expenses hereunder.

25.5 Survival on Termination

The provisions of this Article 25 shall survive Termination.

Article 26

Dispute Resolution

26.1 Dispute Resolution

(i) Any dispute, difference or controversy of whatever nature howsoever arising under or out of or in relation to this Agreement (including its interpretation) between the Parties, and so notified in writing by either Party to the other Party (the "**Dispute**") shall, in the first instance, be attempted to be resolved amicably in accordance with the conciliation procedure set forth in Clause 26.2.

(ii) The Parties agree to use their best efforts for resolving all Disputes arising under or in respect of this Agreement promptly, equitably and in good faith, and further agree to provide each other with reasonable access during normal business hours to all non-privileged records, information and data pertaining to any Dispute.

26.2 Conciliation

In the event of any Dispute between the Parties, either Party may call upon the Authority's Engineer, or such other person as the Parties may mutually agree upon (the "**Conciliator**") to mediate and assist the Parties in arriving at an amicable settlement thereof. Failing mediation by the Conciliator or without the intervention of the Conciliator, either Party may require such Dispute to be referred to the Chairman of the Authority and the Chairman of the Board of Directors of the Contractor for amicable settlement, and upon such reference, the said persons shall meet no later than 7 (seven) business days from the date of reference to discuss and attempt to amicably resolve the Dispute. If such meeting does not take place within the 30 (thirty) business day period or the Dispute is not amicably settled within 30 (thirty) days of the meeting or the Dispute is not resolved as evidenced by the signing of written terms of settlement within 30 (thirty) days of the notice in writing referred to in Clause 26.1.1 or such longer period as may be mutually agreed by the Parties, either Party may refer the Dispute to arbitration in accordance with the provisions of Clause 26.3 but before resorting to such arbitration, the parties agree to explore conciliation by the Conciliation Committees of Independent Experts set up by the Authority in accordance with the procedure decided by the panel of such experts and notified by the Authority on its website including its subsequent amendments. In the event of the conciliation proceedings being successful, the parties to the dispute would sign the written settlement agreement and the conciliators would authenticate the same. Such settlement agreement would then be binding on the parties in terms of Section 73 of the Arbitration Act. In case of failure of the conciliation process even at the level of the Conciliation Committee, either party may refer the Dispute to arbitration in accordance with the provisions of Clause 26.3.

26.3 Arbitration

(i) *Any dispute which remains unresolved between the parties through the mechanisms available/ prescribed in the Agreement, irrespective of any claim value, which has not been agreed upon/ reached settlement by the parties, will be referred to the Arbitral*

Tribunal as per the Arbitration and Conciliation Act.

(ii) Deleted

(iii) The Arbitral Tribunal shall make a reasoned award (the "Award"). Any Award made in any arbitration held pursuant to this Article 26 shall be final and binding on the Parties as from the date it is made, and the Contractor and the Authority agree and undertake to carry out such Award without delay.

(iv) The Contractor and the Authority agree that an Award may be enforced against the Contractor and/or the Authority, as the case may be, and their respective assets wherever situated.

(v) This Agreement and the rights and obligations of the Parties shall remain in full force and effect, pending the Award in any arbitration proceedings hereunder. Further, the parties unconditionally acknowledge and agree that notwithstanding any dispute between them, each Party shall proceed with the performance of its respective obligations, pending resolution of Dispute in accordance with this Article.

(vi) In the event the Party against whom the Award has been granted challenges the Award for any reason in a court of law, it shall make an interim payment to the other Party for an amount equal to 75% (seventy five per cent) of the Award, pending final settlement of the Dispute. The aforesaid amount shall be paid forthwith upon furnishing an irrevocable Bank Guarantee for a sum equal to 120 % (one hundred and twenty per cent) of the aforesaid amount. Upon final settlement of the Dispute, the aforesaid interim payment shall be adjusted and any balance amount due to be paid or returned, as the case may be, shall be paid or returned with interest calculated at the rate of 10% (ten per cent) per annum from the date of interim payment to the date of final settlement of such balance.

26.4 Adjudication by Regulatory Authority, Tribunal or Commission

In the event of constitution of a statutory regulatory authority, tribunal or commission, as the case may be, with powers to adjudicate upon disputes between the Contractor and the Authority, all Disputes arising after such constitution shall, instead of reference to arbitration under Clause 26.3, be adjudicated upon by such regulatory authority, tribunal or commission in accordance with the Applicable Law and all references to Dispute Resolution Procedure shall be construed accordingly. For the avoidance of doubt, the Parties hereto agree that the adjudication hereunder shall not be final and binding until an appeal against such adjudication has been decided by an appellate tribunal or court of competent jurisdiction, as the case may be, or no such appeal has been preferred within the time specified in the Applicable Law.

Article 27

Miscellaneous

27.1 Governing law and jurisdiction

This Agreement shall be construed and interpreted in accordance with and governed by the laws of India, and the courts at Bengaluru shall have exclusive jurisdiction over matters arising out of or relating to this Agreement.

27.2 Waiver of immunity

Each Party unconditionally and irrevocably:

(a) agrees that the execution, delivery and performance by it of this Agreement constitute commercial acts done and performed for commercial purpose;

(b) agrees that, should any proceedings be brought against it or its assets, property or revenues in any jurisdiction in relation to this Agreement or any transaction contemplated by this Agreement, no immunity (whether by reason of sovereignty or otherwise) from such proceedings shall be claimed by or on behalf of the Party with respect to its assets;

(c) waives any right of immunity which it or its assets, property or revenues now has, may acquire in the future or which may be attributed to it in any jurisdiction; and

(d) consents generally in respect of the enforcement of any judgement or award against it in any such proceedings to the giving of any relief or the issue of any process in any jurisdiction in connection with such proceedings (including the making, enforcement or execution against it or in respect of any assets, property or revenues whatsoever irrespective of their use or intended use of any order or judgement that may be made or given in connection therewith).

27.3 Delayed payments

The Parties hereto agree that payments due from one Party to the other Party under the provisions of this Agreement shall be made within the period set forth therein, and if no such period is specified, within 30 (thirty) days of receiving a demand along with the necessary particulars. In the event of delay beyond such period, the defaulting Party shall pay interest for the period of delay calculated at a rate equal to Base Rate plus 2 (two) percent, calculated at quarterly rests, and recovery thereof shall be without prejudice to the rights of the Parties under this Agreement including Termination thereof.

27.4 Waiver

(i) Waiver, including partial or conditional waiver, by either Party of any default by the other Party in the observance and performance of any provision of or obligations under this Agreement:-

(a) shall not operate or be construed as a waiver of any other or subsequent default hereof or of other provisions of or obligations under this Agreement;

(b) shall not be effective unless it is in writing and executed by a duly authorised representative of the Party; and

(c) shall not affect the validity or enforceability of this Agreement in any manner.

(ii) Neither the failure by either Party to insist on any occasion upon the performance of the terms, conditions and provisions of this Agreement or any obligation thereunder nor time or other indulgence granted by a Party to the other Party shall be treated or deemed as waiver of such breach or acceptance of any variation or the relinquishment of any such right hereunder.

27.5 Liability for review of Documents and Drawings Except

to the extent expressly provided in this Agreement:

(a) no review, comment or approval by the Authority or the Authority's Engineer of any Document or Drawing submitted by the Contractor nor any observation or inspection of the construction, or maintenance of the Project Road nor the failure to review, approve, comment, observe or inspect hereunder shall relieve or absolve the Contractor from its obligations, duties and liabilities under this Agreement, the Applicable Laws and Applicable Permits; and

(b) the Authority shall not be liable to the Contractor by reason of any review, comment, approval, observation or inspection referred to in Sub-clause (a) above.

27.6 Exclusion of implied warranties etc.

This Agreement expressly excludes any warranty, condition or other undertaking implied at law or by custom or otherwise arising out of any other agreement between the Parties or any representation by either Party not contained in a binding legal agreement executed by both Parties.

27.7 Survival

(i) Termination shall:

(a) not relieve the Contractor or the Authority, as the case may be, of any obligations hereunder which expressly or by implication survive Termination hereof; and

(b) except as otherwise provided in any provision of this Agreement expressly limiting the liability of either Party, not relieve either Party of any obligations or liabilities for loss or damage to the other Party arising out of, or caused by, acts or omissions of such Party prior to the effectiveness of such Termination or arising out of such Termination.

(ii) All obligations surviving Termination shall only survive for a period of 3 (three) years following the date of such Termination.

27.8 Entire Agreement

This Agreement and the Schedules together constitute a complete and exclusive statement of the terms of the agreement between the Parties on the subject hereof, and no amendment or modification hereto shall be valid and effective unless such modification or amendment is agreed to in writing by the Parties and duly executed by persons especially empowered in this behalf by the respective Parties. All prior written or oral understandings, offers or other communications of every kind pertaining to this Agreement are abrogated and withdrawn. For the avoidance of doubt, the Parties hereto agree that any obligations of the Contractor arising from the Request for Qualification or Request for Proposals, as the case may be, shall be deemed to form part of this Agreement and treated as such.

27.9 Severability

If for any reason whatever, any provision of this Agreement is or becomes invalid, illegal or unenforceable or is declared by any court of competent jurisdiction or any other instrumentality to be invalid, illegal or unenforceable, the validity, legality or enforceability of the remaining provisions shall not be affected in any manner, and the Parties will negotiate in good faith with a view to agreeing to one or more provisions which may be substituted for such invalid, unenforceable or illegal provisions, as nearly as is practicable to such invalid, illegal or unenforceable provision. Failure to agree upon any such provisions shall not be subject to the Dispute Resolution Procedure set forth under this Agreement or otherwise.

27.10 No partnership

This Agreement shall not be interpreted or construed to create an association, joint venture or partnership between the Parties, or to impose any partnership obligation or liability upon either Party, and neither Party shall have any right, power or authority to enter into any agreement or undertaking for, or act on behalf of, or to act as or be an agent or representative of, or to otherwise bind, the other Party.

27.11 Third parties

This Agreement is intended solely for the benefit of the Parties and their respective successors and permitted assigns, and nothing in this Agreement shall be construed to create any duty to, standard of care with reference to, or any liability to, any person not a Party to this Agreement.

27.12 Successors and assigns

This Agreement shall be binding upon, and inure to the benefit of the Parties and their respective successors and permitted assigns.

27.13 Notices

Any notice or other communication to be given by any Party to the other Party under or in connection with the matters contemplated by this Agreement shall be in writing and shall:

(a) in the case of the Contractor, be given by facsimile or e-mail and by letter delivered by hand to the address given and marked for attention of the person set out below or to such other person as the Contractor may from time to time designate by notice to the Authority; provided that notices or other communications to be given to an address outside Bengaluru may, if they are subsequently confirmed by sending a copy thereof by registered acknowledgement due, air mail or by courier, be sent by facsimile or e-mail to the person as the Contractor may from time to time designate by notice to the Authority;

Name:

Designation:

Address:

(b) in the case of the Authority, be given by facsimile or e-mail and by letter delivered by hand and be addressed to the [Chairman] of the Authority with a copy delivered to the Authority Representative or such other person as the Authority may from time to time designate by notice to the Contractor; provided that if the Contractor does not have an office in Bengaluru it may send such notice by facsimile or e-mail and by registered acknowledgement due, air mail or by courier; and

(c) any notice or communication by a Party to the other Party, given in accordance herewith, shall be deemed to have been delivered when in the normal course of post it ought to have been delivered and in all other cases, it shall be deemed to have been delivered on the actual date and time of delivery; provided that in the case of facsimile or e- mail, it shall be deemed to have been delivered on the working day following the date of its delivery.

27.14 Language

All notices required to be given by one Party to the other Party and all other communications, Documentation and proceedings which are in any way relevant to this Agreement shall be in writing and in English language.

27.15 Counterparts

This Agreement may be executed in two counterparts, each of which, when executed and delivered, shall constitute an original of this Agreement.

27.16 Confidentiality

The Parties shall treat the details of this Agreement as private and confidential, except

to the extent necessary to carry out obligations under it or to comply with Applicable Laws. The Contractor shall not publish, permit to be published, or disclose any particulars of the Works in any trade or technical paper or elsewhere without the previous agreement of the Authority.

27.17 Copyright and Intellectual Property rights

(i) As between the Parties, the Contractor shall retain the copyright and other Intellectual Property rights in the Contractor's documents and other design documents made by (or on behalf of) the Contractor. The Contractor shall be deemed (by signing this Agreement) to give to the Authority a non-terminable transferable non-exclusive royalty-free licence to copy, use and communicate the Contractor's documents, including making and using modifications of them. This licence shall:

(a) apply throughout the actual or intended working life (whichever is longer) of the relevant parts of the Works;

(b) entitle any person in proper possession of the relevant part of the Works to copy, use and communicate the Contractor's documents for the purposes of completing, operating, maintaining, altering, adjusting, repairing and demolishing the Works; and

(c) in the case of Contractor's documents which are in the form of computer programs and other software, permit their use on any computer on the Site and other places as envisaged by this Agreement, including replacements of any computers supplied by the Contractor.

(ii) The Contractor's documents and other design documents made by (or on behalf of) the Contractor shall not, without the Contractor's consent, be used, copied or communicated to a third party by (or on behalf of) the Authority for purposes other than those permitted under this Clause 27.17.

(iii) As between the Parties, the Authority shall retain the copyright and other intellectual property rights in this Agreement and other documents made by (or on behalf of) the Authority. The Contractor may, at its cost, copy, use, and obtain communication of these documents for the purposes of this Agreement. They shall not, without the Authority's consent, be copied, used or communicated to a third party by the Contractor, except as necessary for the purposes of the contract.

27.18 Limitation of Liability

(i) Neither Party shall be liable to the other Party for loss of use of any Works, loss of profit, loss of any contract or for any indirect or consequential loss or damage which may be suffered by the other Party in connection with this Agreement, save and except as provided under Articles 23 and 25.

(ii) The total liability of one Party to the other Party under and in accordance with the provisions of this Agreement, save and except as provided in Articles 23 and 25, shall not exceed the Contract Price. For the avoidance of doubt, this Clause shall not limit the liability in any case of fraud, deliberate default or reckless misconduct by the defaulting

Party.

27.19 Care and Supply of Documents

(i) Each of the Contractor's documents shall be in the custody and care of the Contractor, unless and until taken over by the Authority. Unless otherwise stated in the Agreement, the Contractor shall supply to the Authority 2 (two) copies of the each of the Contractor's documents.

(ii) The Contractor shall keep, on the Site, a copy of the Agreement, publication named in the Authority's requirements, the Contractor's documents, and variations and other communications given under the Agreement. The Authority's personnel shall have the right of access to all these documents at all reasonable times.

(iii) If a Party becomes aware of an error or defect of a technical nature in a document which was prepared for use in executing the Works, the Party shall promptly give notice to the other party of such error or defect.

27.20 Authority's Use of Contractor's Documents.

(i) As between the Parties, the Contractor shall retain the copyright and other Intellectual Property rights in the Contractor's Documents and other design documents made by (or on behalf of) the Contractor.

(ii) The Contractor hereby gives to the Authority a non-terminable transferable nonexclusive royalty-free license to copy, use and communicate the Contractor's Documents, including making and using modifications of them. This license shall:

(a) apply through out the actual or intended working life (whichever is longer) of the relevant parts of the Works,

(b) entitle any person in proper possession of the relevant part of the Works to copy, use and communicate the Contractor's Documents for the purposes of completing, operating, maintaining, altering, adjusting, repairing and demolishing the Works, and

(c) in the case of Contractor's Documents which are in the form of computer programs and other software, permit their use on any computer on the Site and other places as envisaged by the Contractor, including replacements of any computers supplied by the Contractor.

(iii) The Contractor's Documents and other design documents made by or on behalf of the Contractor shall not, without the Contractor's consent, be used, copied or communicated to a third party by (or on behalf of) the Authority for purposes other than those permitted under this Sub-Clause.

27.21 Contractor's Use of Authority's Documents

As between the Parties, the Authority shall retain the copyright and other intellectual property rights in the Authority's requirements and other Documents made by (or on behalf of) the Authority. The Contractor may, at its cost copy, use, and obtain communication of these documents for the purpose of the Agreement. They shall not

without the Authority's consent, be copied, used or communicating to a third party by the Contractor, except as necessary for the purposes of the Agreement.

27.22 Access to the Site by Others

The Contractor shall, at all times, afford access to the Site to the authorized representatives of the Authority, the Authority's Engineer and anyone else authorized by the Authority to access the site and to the persons duly authorized by any Governmental Agency having jurisdiction over the Project, including those concerned with safety, security or environmental protection to inspect the Project Road and to investigate any matter within their authority and upon reasonable notice, the Contractor shall provide to such persons reasonable assistance necessary to carry out their respective duties and functions with minimum disruption to the construction, operation and maintenance of the Project Road consistent with the purpose for which such persons have gained such access to the Site.

27.23 Term

This Agreement shall come into force and effect from the date first hereinabove written and shall remain in force and effect till the Termination Date i.e. the Parties perform all their respective obligations or is terminated by any of the Parties for the reasons and in the manner provided for in the Agreement.

27.24 Amendments

The Agreement may not be supplemented, amended, modified or changed except by an instrument in writing signed by the Contractor and the Authority and expressed to be a supplement, modification or change to the Agreement.

27.25 Representation and Bribes

The Contractor represents and warrants to the Authority that:

(a) No representation or warranty by the Contractor contained herein or in any other document furnished by it to the Authority, or to any Governmental Instrumentality in relation to Applicable Permits contains or will contain any untrue statement of material fact or omits or will omit to state a material fact necessary to make such representation or warranty not misleading; and

(b) It warrants that no sums, in cash or kind, have been paid or will be paid by or on behalf of the Contractor, to any person by way of fees, commission or otherwise for securing or entering into the Contractor for influencing or attempting to influence any officer or employee of the Authority or GOI in connection therewith.

27.26 No Agency

The Agreement does not constitute either Party as the agent, partner or legal representative of the other for any purposes whatsoever, and neither Party shall have

any express or implied right or authority to assume or to create any obligation or responsibility on behalf of or in the name of the other Party.

Schedules

Schedule-A

(See Clauses 2.1 and 8.1)

Site of the Project

1 The Site

(i) Site of the Project Road shall include the land, buildings, structures and road works as described in Annex-I of this Schedule-A.

(ii) The dates of handing over the Right of Way to the Contractor are specified in Annex-II of this Schedule-A.

(iii) An inventory of the Site including the land, buildings, structures, road works, trees and any other immovable property on, or attached to, the Site shall be prepared jointly by the Authority Representative and the Contractor, and such inventory shall form part of the memorandum referred to in Clause 8.2 (i) of this Agreement.

(iv) The alignment plans of the Project Road are specified in Annex-III. In the case of sections where no modification in the existing alignment of the Project Road is contemplated, the alignment plan has not been provided. Alignment plans have only been given for sections where the existing alignment is proposed to be upgraded. The proposed profile of the Project Roads shall be followed by the contractor with minimum FRL as indicated in the alignment plan. The Contractor, however, improve/upgrade the Road Profile as indicated in Annex-III based on site/design requirement.

(v) The status of the environment clearances obtained or awaited is given in Annex-IV.

Annex – I

(Schedule-A)

Site for Project Road

1. Site

The Site of the project road 3-Lane Bi-Directional Road Underpass on Bellary Road between Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU), starts at the Hebbal Junction and ends at UAS Staff quarters. In between the Underpass passes through the Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU).

The Start and End Chainages coordinates are

Sr. No.	Easting	Northing	Remarks
1	781058.490m	1443739.123 m	Start Point Near Hebbal Lake (RHS)
2	781109.283m	1443577.343 m	Start Point Near Hebbal Junction (LHS)
3	780526.738m	1441946.940 m	End Point Near UAS Staff Quarters

(i) Description of the Project Road

Project is the construction of 3-Lane Bi-Directional Road Underpass connecting Hebbal Junction to UAS Staff quarters on Bellary Road by cut & cover method including electromechanical and tunnel ventilation system. It will include Rail Under Bridge (Box Pushing).

(ii) Terrain

The terrain along the project stretch is 'plain' terrain.

2. Land

The Site of the Project Road comprises the land (sum total of land already in possession and land to be possessed) as described below:

S. No.	From	To	ROW (m)	Remarks
(1)	(2)		(3)	(4)
1	0+000	0+415	24.25	RHS Ramp
2	0+000	0+390	24.25	LHS Ramp
3	0+415 (0+390)	0+600 (0+550)	62.00	Width of ROW
4	0+600	0+810	24.25	RHS Ramp
5	0+550	0+760	24.25	LHS Ramp
6	0+810	2+228	37.50	Width of ROW
7	0+760	2+180		

3. Carriageway

Since, the project is construction of 3 Lane bidirectional underpass providing connectivity

Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU) Campus. Therefore, there is no existing carriageway except end point of project.

At the end of project: Project ends next to UAS Staff quarters on Bellary roads. Where existing road configuration is 6 lanes with Service roads.

4. Major Bridges

The Site includes the following Major Bridges:

S. No.	Chainage (km)	Type of Structure			No. of Spans with span length (m)	Width (m)
		Foundation	Sub-structure	Super-structure		
Nil						

5. Road over-bridges (ROB)/ Road under-bridges (RUB)

The Site includes the following ROB (road over railway line)/RUB (road under railway line):

S. No.	Chainage (km)	Type of Structure		No. of Spans with span length (m)	Width (m)	ROB/ RUB
		Foundation	Superstructure			
Nil						

6. Grade separators

The Site includes the following grade separators:

S. No.	Chainage (km)	Type of Structure		No. of Spans with span length (m)	Width (m)
		Foundation	Superstructure		
Nil					

7. Minor bridges

The Site includes the following minor bridges:

S. No.	Chainage (km)	Type of Structure			No. of Spans with span length (m)	Width (m)
		Foundation	Sub-structure	Super-structure		
Nil						

8. Railway level crossings

The Site includes the following railway level crossings:

S. No.	Location (km)	Remarks
1	Design Km. 0+627 to Km 0+647 (LHS Tube) and, Km 0+686 to Km 0+706. (RHS Tube).	Near Hebbal Railway Station , Yashwantpuram to Selam Line. Chainage mentioned on Railway line : 217/000

9. KRIDE Crossing (Elevated-Under Construction)

S. No	Location (Km)	Remarks
1	Design Km. 0+610 (LHS Tube) and, Km 0+668 (RHS Tube).	Near Hebbal,

10. Underpasses (vehicular, non-vehicular)

The Site includes the following vehicular underpasses:

S. No.	Chainage (km)	Type of Structure	No. of Spans with span length (m)	Width (m)
1	Design Km. 1+937 (LHS Tube) and, 1+985 (RHSTube).	Box Structure	2 Nos.	2 m each

11. Loop/Ramp of Flyover

The project passes through the one down ramp of Hebbal Flyover (Towards Yeshwantpura.

S. No.	Location (km)	Remarks
1	Design Km. 0+627 to Km 0+647 (LHS Tube) and, Km 0+686 to Km 0+706. (RHS Tube).	Hebbal Flyover (Towards Yeshwantpura)

12. Culverts

The Site has the following culverts:

S. No.	Chainage (km)	Type of Culvert	Span /Opening with span length (m)	Width (m)
Nil				

13. Bus bays

The details of bus bays on the Site are as follows:

S. No.	Chainage (km)	Length (m)	Left Hand Side	Right Hand Side
1	Nil			
2	Nil			

14. Truck Lay byes

The details of truck lay byes are as follows:

S. No.	Chainage (km)	Length (m)	Left Hand Side	Right Hand Side
Nil.				

15. Roadside drains (Tunnel Roadside Drain)

The details of the roadside drains are as follows:

S. No.	Location		Type	
	From km	to km	Masonry/cc (Pucca)	Earthen (Kutcha)
As per the approved plan length				

16. Major junctions

The details of major junctions are as follows:

S. No.	Location		At grade	Separated	Category of Cross Road	Details
	From km	To km				
1	Km 0+300 (LHS Tube)	Km 0+400 (LHS Tube)	Yes	Yes	NH	Hebbal Junction

(NH: National Road, SH: State Road, MDR: Major District Road)

17. Minor junctions

The details of the minor junctions are as follows:

S. No.	Location		Type	
	From km	To km	T -junction	Cross road
Nil.				

18. Bypasses

The details of the existing road sections proposed to be bypassed are as follows:

S. No.	Name of bypass (town)	Chainage (km) From km to km	Length (in Km)
Nil			

Annex – II

(As per Clause 8.3 (i))

(Schedule-A)

Dates for providing Right of Way of Construction Zone

The dates on which the Authority shall provide Right of Way of Construction Zone to the Contractor on different stretches of the Site are stated below:

Sl. No	From	To	Length (m)	Width (m)	Remarks	Date of providing Right of Way*
(1)	(2)		(3)	(4)	(5)	(6)
Full Right of Way (full width)/ Part Right of Way (part width)/ Balance Right of Way (width)	0+000	0+415	415	24.25	RHS Ramp	
	0+000	0+390	390	24.25	LHS Ramp	
	0+415 (0+390)	0+600 (0+550)	185/160	62.00	Width of ROW	
	0+600	0+810	210	24.25	RHS Ramp	
	0+550	0+760	210	24.25	LHS Ramp	
	0+810	2+228	1418	37.50	Width of ROW	
	0+760	2+180	1420			

*The dates specified herein shall in no case be beyond 150 (one hundred and fifty) days after the Appointed Date.

Annex - III *(Schedule-A)*

Alignment Plans



Annex – IV

(Schedule-A)

Environment Clearances

1. Environment Clearances As per EIA notification 2006 and its amendment S.O.2559 (E) Dated 22nd August 2013, Expansion of National Highways greater than 100 km involving additional right of way or land acquisition greater than 40m on existing alignments and 60m on re-alignments or bypasses, Environmental Clearance Exempted from the purview of the Environmental Impact Assessment.
2. The proposed tunnel project does not lie within a National Highway (NH) or State Highway (SH) corridor, but within an Urban Road network. Although designed to NH standards for mobility and operational efficiency, it does not come under the EIA Notification, 2006, in view of S.O.1533 dt 14th September 2006 and its Amendment S.O 2559(E) dated 22.08.2013. Accordingly, the project is exempted.
3. However, a Site-/Project-Specific Environmental Management Plan (EMP) shall be prepared by the Concessionaire during the Design Stage, in accordance with the applicable MoEF&CC and State Government guidelines. The prescribed mitigation measures shall be implemented prior to the commencement of construction, and environmental compliance monitoring shall be undertaken throughout the construction period. Quarterly and half-yearly Environmental Monitoring Reports shall be submitted to the Competent Authority, as per statutory requirements.
4. As per the tree inventory, 545 trees are affected. Accordingly, tree felling permission shall be obtained from the competent authority. Compensatory afforestation/plantation shall be carried out in accordance with the applicable State laws and regulations.

   The survival rate of the planted trees shall be not less than 85% for a period of 18 months.

Schedule - B

(See Clause 2.1)

Development of the Project Road

1. Development of the Project Road

Development of the Project Road shall include design and construction of the Project Road as described in this Schedule-B and in Schedule-C.

2. Specifications and Standards

The Project Road shall be designed and constructed in conformity with the Specifications and Standards specified in Annex-I of Schedule-D.

Annex – I

(Schedule-B)

Description of Project Road

1. Construction of 3-Lane Bi-Directional Road Underpass

(i) The Project Road shall follow the existing alignment unless otherwise specified by the Authority and shown in the alignment plans specified in **Annex-III of Schedule-A.**

(ii) **Width of Carriageway**

For a three-lane uni-directional under pass. The carriageway shall be three lanes (10. 5 m) in accordance with the typical cross sections.

The kerb syness, crash barrier and raised footpath/walkway shall be as per typical cross sections.

(iii) **Vertical clearance**

Minimum 7.5 m vertical clearance shall be ensured for traffic clearance (5.5 meters) and for ventilation & variable message signages (2 meters).

(iv) **Cross Passages**

The main tunnel tubes shall be connected through cross passage at an interval of 500 m as per IRC: SP:91-2019.

(v) **Emergency Laybys**

The emergency Laybys shall not be provided.

(vi) **Ventilation for Underpass**

Longitudinal ventilation System shall be provided for the project as per technical specification and guidelines for Road Tunnel IRC:SP:91-2019., NFPA 502 (2017), PIARC Technical Committee C4- Road Tunnels: Vehicle Emission and Air Demand for Ventilation (2011).

(vii) **Lighting Electrical and Mechanical Facilities**

The electrical and Mechanical works includes streetlights, Lighting in Open cut, Box structure, Ventilation for Box Tunnel, Firefighting & firefighting installation, water sprinkling system & plumbing Drainage system shall be provided as per the Technical Specifications and Guidelines for Road Tunnels IRC: SP: 91-2019.

Normal Lighting & Emergency Lighting in the Road tunnel shall be designed according to the Technical Specifications and CIE 88:2004 standard "Guide for the Lighting of Road Tunnels and Underpasses" for two- way traffic including Cable & cable laying, Main Electrical panel & Sub Panels, earthing of complete system, galvanized supporting structure and all other necessary accessories, etc. and as per the Guidelines for Road Tunnels IRC: SP: 91-2019. The light intensity of the entry and exit zones shall be adapted to the actual outside

lighting level according to external conditions (day/night, regulation through measurement of luminous density).

Tunnel safety facilities such as CCTV- cameras, traffic lights, variable message signs, traffic loop detectors, emergency communications, alarm push buttons, fire detection systems etc. shall be provided as per the Technical Specifications and Guidelines for Road Tunnels IRC: SP: 91-2019.

(viii) **Drainage system in Underpass**

The tunnel shall be designed as a dry and drained tunnel. The drainage system of underpass with Cut & Cover & Open cut sections shall be as indicated in the Typical cross section.

The Contractor shall design the drainage along the underpass in such a way that the outfall of drainage system to be connected with nearby municipal drainage system having adequate capacity as per required discharge. The drainage plan prepared by the Contractor shall be approved by AE and consented by concerned Government Authorities to connect the Tunnel drainage system with municipal drainage system.

For urban tunnel roadways and approach roads that are subjected to frequent passage of heavy motor vehicles—including buses, trucks, and emergency vehicles—the design and thickness of drain covers must be aligned with Class D400 to F900 of EN 124 or equivalent Indian standards. These classifications represent the heaviest permissible loads encountered in urban and industrial road environments.

Each cover and frame combination must be lab-tested for static and dynamic load-bearing performance to verify that it can safely handle:

- Axle loads up to 11.5 tonnes, as per IRC:6 or equivalent AASHTO standards.
- Wheel pressure and impact loading associated with sudden braking or turning of trucks and buses.

Furthermore, the design shall ensure:

- Minimal deflection (<1 mm under full load) to prevent rattling.
- Proper seating and locking to avoid displacement under impact.
- Corrosion protection through hot-dip galvanization (for steel) or bituminous/epoxy coating (for iron).

To ensure long-term performance, all covers installed in heavy-traffic tunnel sections must be periodically inspected for cracking, deflection, and corrosion—especially after monsoon or high-traffic events.

(ix) **Project Facilities**

As per Schedule-C.

(x) **Typical Cross Sections and Schedules**

The cross Sections of for the Underpass and its approaches should be as indicated in **Appendix B-I.** The TCS Schedules are mentioned below,

Table: TCS Schedule

Hebbal to UAS Quarters Entry (UP RAMP) LHS				
Sr. No.	**Form**	**To**	**Length (m)**	**TCS Type**
1	00+000	00+250	250	TCS-1
2	00+250	00+627	377	TCS-2
3	00+627	00+647	20	As per GAD
4	00+647	00+950	303	TCS-2
5	00+950	01+950	1000	TCS-3
6	01+950	02+180	230	TCS-4
	Total Length		2180 m	

Table: TCS Schedule

Hebbal TO UAS Quarters Exit (DOWN RAMP) RHS				
Sr. No.	**Form**	**To**	**Length (m)**	**TCS Type**
1	00+000	00+250	250	TCS-1A
2	00+250	00+565	315	TCS-2A
3	00+565	00+686	121	TCS-2
4	00+686	00+706	20	As per GAD
5	00+706	01+000	294	TCS-2
6	01+000	02+000	1000	TCS-3
7	02+000	02+228	228	TCS-4
	Total Length		2228 m	

(xi) **Alignment Plan and Longitudinal Section**

The Indicated alignment plan and vertical profile of Underpass shall be as given in **Appendix B-II**

(xii) **Existing Road Connectivity**

The provision of existing road connectivity shall be at the approach of Underpass as per indicative Alignment Plan and Vertical profile which is attached as Appendix: B-I. The existing road connectivity shall be constructed with merging and diverging at the start and end locations of the project as per approval of Authority Engineers or Authority.

Sr. No.	Details	Length	Side	Remarks
1	**At Start of Project RHS**	**220 m**	**RHS**	**At Hebbal Lake side**
2	**At start of project LHS**	**300 m**	**LHS**	**At Hebbal Junction side**
3	**At end of project near UAS quarters**	**LHS 550 m RHS 500 m**	**Both**	**On Bellary Road near UAS Quarters.**

2. Geometric Design and General Features

(i) **General**

Geometric design and general features of the Project Road shall be in accordance with IRC:86-2018 (Geometric Design Standards for Urban Roads and Streets), IRC:SP:91-2019 (Guidelines for Road Tunnels), IRC:38-1988 Guidelines for Design of Horizontal

Curves for Highway and Design Tables, IRC: SP:23-1993 Vertical Curves of Highway.

(ii) **Design speed**

The design speed shall be the minimum of 60 kmph as per IRC:86-2018 (Geometric Design Standards for Urban Roads and Streets).

(iii) **Vertical Gradient**

The Vertical gradient for the project road shall be as per plan and profile as annexed in Appendix-BII. However, the vertical gradient shall not be more than 4% except at the ramp/approach locations.

(iv) **Pavement**

The RCC wearing coat of 75 mm above the bottom slab shall be as per the MoRTH Specification.

(v) **Improvement of the existing road geometrics**

In the following sections, where improvement of the existing road geometrics to the prescribed standards is not possible, the existing road geometrics shall be improved to the extent possible within the given right of way and proper road signs and safety measures shall be provided:

Sl. No.	Stretch (from km to km)	Type of deficiency	Remarks
Nil.			

3. Right of Way

Details of the Right of Way are given in Annex II of Schedule-A.

4. Traffic Control Devices and Road Safety

Traffic control devices and road safety work shall be provided in accordance with IRC 67, IRC:SP:91**.**

5. Traffic Signs

Traffic signs shall be provided as per IRC 67 as mentioned in Schedule-C**.**

6. Pavement Marking

Pavement markings shall be completed as per IRC 35 as mentioned in Schedule-C

7. Road Side Furniture

It shall be provided as mentioned in Schedule C.

8. Diversion Plan

The traffic diversion plans shall be prepared as per IRC SP 55 for smooth flow of traffic and

safety. During the construction of cut and cover the diversion plan is to be prepared as per IRC:SP:55-2018. And the provision of traffic decking is to be done as per site specific requirement for smooth flow of traffic during construction.

9. Compulsory Afforestation

Shall be as per Schedule A.

10. Hazardous Locations

The safety barriers shall also be provided at the following hazardous locations**:**

Sl. No.	Location stretch from (km) to (km)	LHS/RHS
Nil		

11. Dumping Sites

Undertake extraction, transport & disposal of muck, soil, earth. No land shall be provided by the Authority for the same. In case government land is available, the same may be made available to the Contractor on a lease basis as per guidance value. Additionally, if there are lands identified where muck is required by the Authority for levelling purpose, the Contractor must dispose the muck at these sites (including levelling) free of cost.
The Contractor will have to present a Muck Disposal Plan according to the applicable rules and regulations of government of Karnataka and Government of India.
However, the material obtained from tunnel excavation, if suitable, may be used by the Contractor for refilling and restoration purposes within the Project Road. The excavated material must not be used by the Contractor for commercial purposes.

12. Change of Scope

The length of Structures and bridges specified hereinabove shall be treated as an approximate assessment. The actual lengths as required on the basis of detailed investigations shall be determined by the Contractor in accordance with the Specifications and Standards. Any variations in the lengths specified in this Schedule-B shall not constitute a Change of Scope, save and except any variations in the length arising out of a Change of Scope expressly undertaken in accordance with the provisions of Article 13.

13. Service roads

Service roads shall be constructed at the locations and for the lengths indicated below:
[Refer to the provision of relevant Manual and provide details]

Sl. No.	Location of service road (from km to km)	Right hand side (RHS)/Left hand side (LHS)/ or Both sides	Length (km) of service road
Nil.			

14. Road Embankment and Cut Section

Nil

15. Design of Structures

(i) General

(a) All bridges, culverts and structures shall be designed and constructed in accordance with the provision of relevant Manual and shall conform to the cross-sectional features and other details specified therein.

(b) All bridges shall be high-level bridges. **- Nil**

(c) The following structures shall be designed to carry utility services specified in table below:

[Refer to the provision of relevant Manual and provide details]

Sl. No.	Bridge at km	Utility service to be carried	Remarks
Nil			

(d) Cross-section of the new culverts and bridges at deck level for the Project Road shall conform to the typical cross-sections given in the provision of relevant Manual**.- Nil.**

(ii) Culverts -**Nil.**

(iii) Bridges-**Nil.**

(iv) Rail-road bridges – **Nil**

(v) Rail Under Bridge-

S. No.	Location (km)	Remarks
1	Design Km. 0+627 to Km 0+647 (LHS Tube) and, Km 0+686 to Km 0+706. (RHS Tube).	Near Hebbal,

Construction of Road Under Bridge (RUB)/Subway by RCC box pushing method under existing running railway track/embankment, including complete sequence from soil investigation to commissioning. Covers thrust/casting bed, RCC box fabrication/pushing, rail cluster/rolling assemblies, approaches, retaining walls, drainage (anti-waterlogging), roadworks, waterproofing, track restoration, and all temporary/protection works including minimal traffic blocks per RDSO and Railway Board guidelines.

(vi) Grade separated structures – **Nil**.

(vii) Repairs and strengthening of bridges and structures - **Nil**

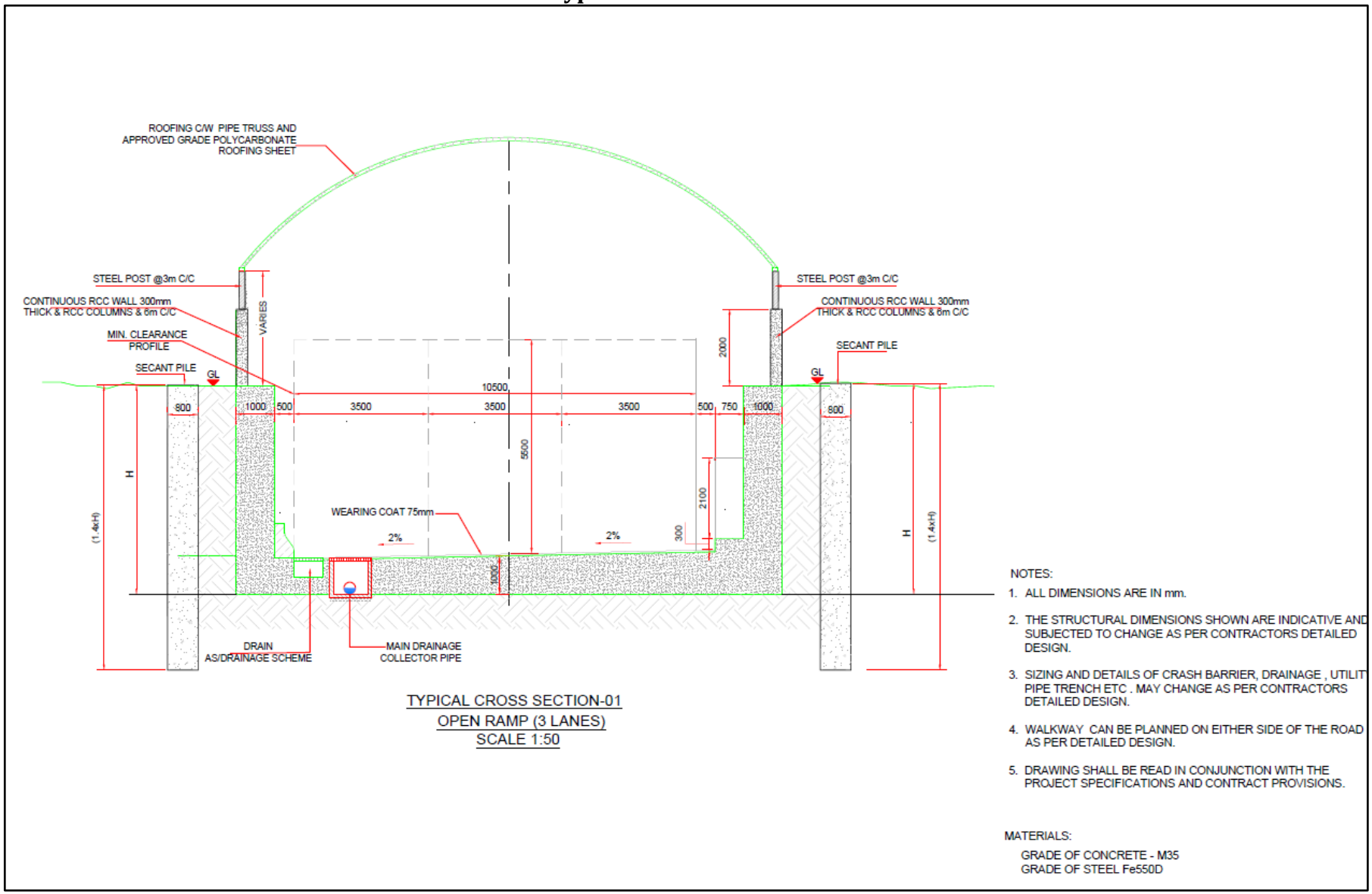
(Schedule B-1)

1. The shifting of utilities, dismantling of structures and felling of trees shall be carried out by them as per Article 9 of Contract Agreement.
    a. The Cost of shifting of utilities shall be considered as Change of Scope to paid as at the estimated cost approved by utility owning agency.
    b. The Cost of felling & translocation of trees and dismantling of structures shall be included in the lump sum quote of the Contractor.

Sr. No	Type of Utility	Unit	Quantity	Location/stretch (LHS/RHS)
A	Electrical Utilities			
A1	Electrical Poles	Nos.		
A2	Electrical cables	meters		
A3	Transformers	Nos.		
-	------	--		
-	-------	--		
B	Water/Sewage pipeline			
B1	Sewage	meters		
B2	Water supply	meters		
-	-------	--		
-	-------	--		
C	Felling of Tress	Nos.		

Appendix B-I

Typical Cross Sections



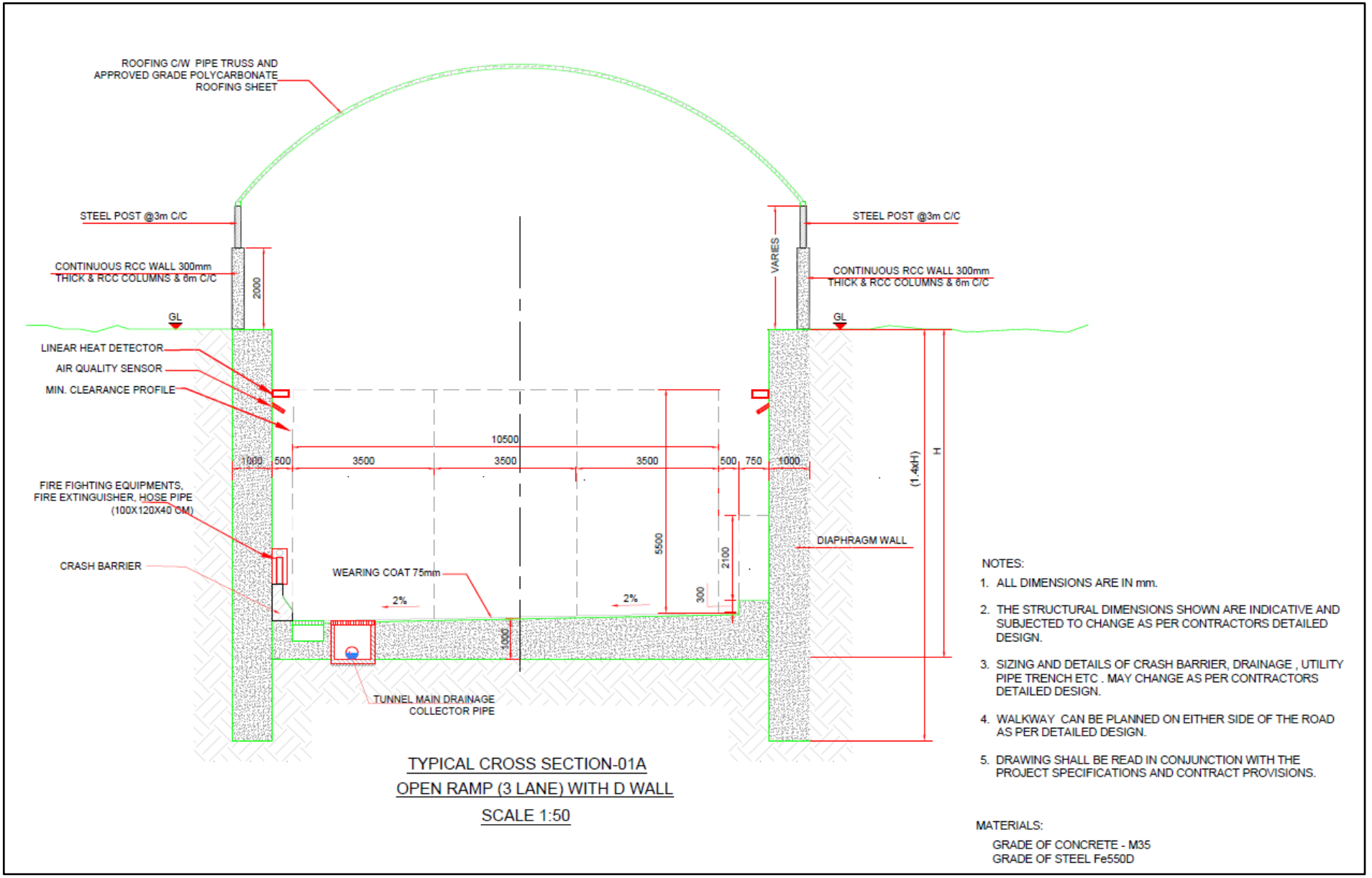
TYPICAL CROSS SECTION-01
OPEN RAMP (3 LANES)
SCALE 1:50

NOTES:

1. ALL DIMENSIONS ARE IN mm.
2. THE STRUCTURAL DIMENSIONS SHOWN ARE INDICATIVE AND SUBJECTED TO CHANGE AS PER CONTRACTORS DETAILED DESIGN.
3. SIZING AND DETAILS OF CRASH BARRIER, DRAINAGE , UTILIT PIPE TRENCH ETC . MAY CHANGE AS PER CONTRACTORS DETAILED DESIGN.
4. WALKWAY CAN BE PLANNED ON EITHER SIDE OF THE ROAD AS PER DETAILED DESIGN.
5. DRAWING SHALL BE READ IN CONJUNCTION WITH THE PROJECT SPECIFICATIONS AND CONTRACT PROVISIONS.

MATERIALS:

GRADE OF CONCRETE - M35
GRADE OF STEEL Fe550D



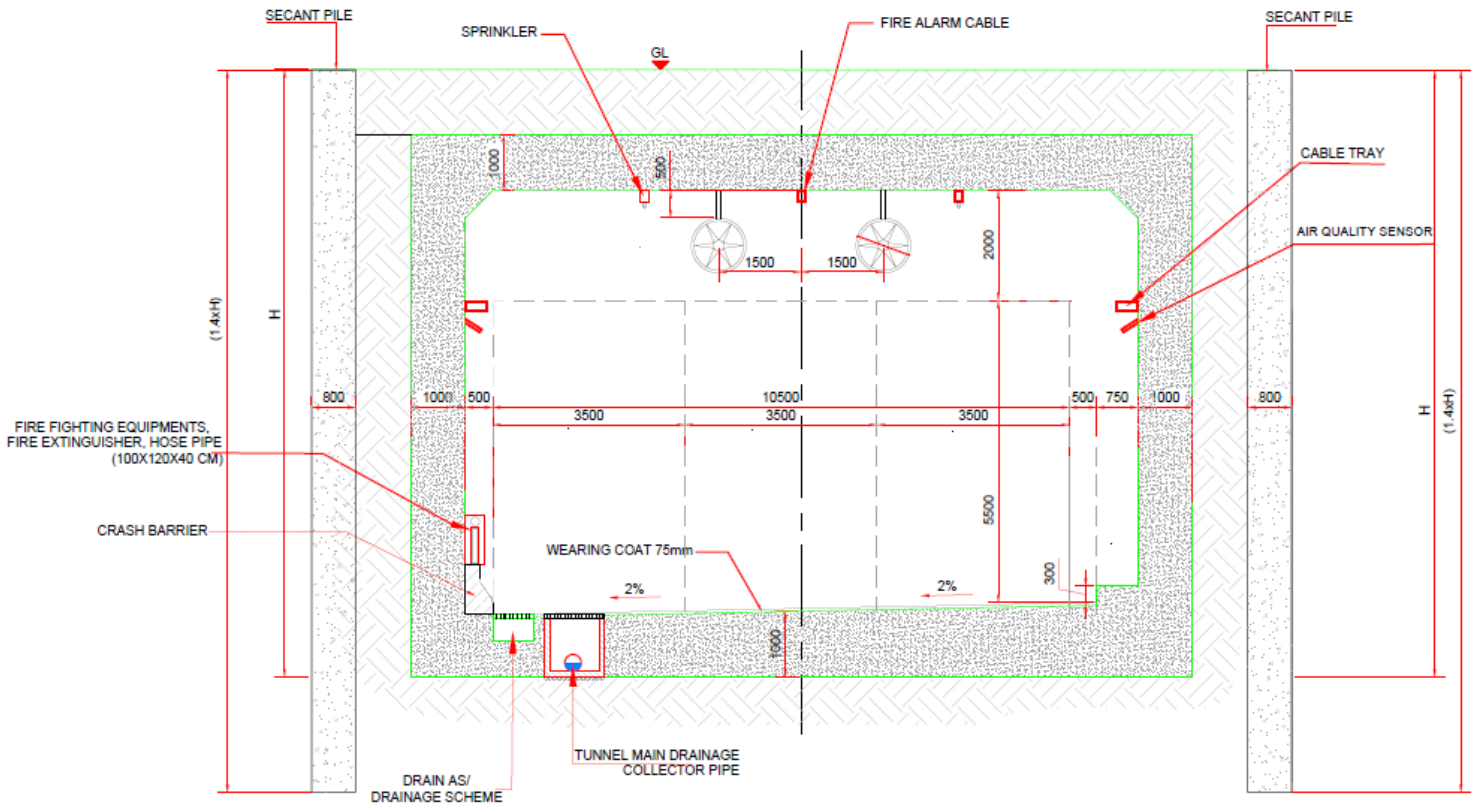
TYPICAL CROSS SECTION-01A
OPEN RAMP (3 LANE) WITH D WALL
SCALE 1:50

NOTES:

1. ALL DIMENSIONS ARE IN mm.
2. THE STRUCTURAL DIMENSIONS SHOWN ARE INDICATIVE AND SUBJECTED TO CHANGE AS PER CONTRACTORS DETAILED DESIGN.
3. SIZING AND DETAILS OF CRASH BARRIER, DRAINAGE , UTILITY PIPE TRENCH ETC . MAY CHANGE AS PER CONTRACTORS DETAILED DESIGN.
4. WALKWAY CAN BE PLANNED ON EITHER SIDE OF THE ROAD AS PER DETAILED DESIGN.
5. DRAWING SHALL BE READ IN CONJUNCTION WITH THE PROJECT SPECIFICATIONS AND CONTRACT PROVISIONS.

MATERIALS:

GRADE OF CONCRETE - M35
GRADE OF STEEL Fe550D



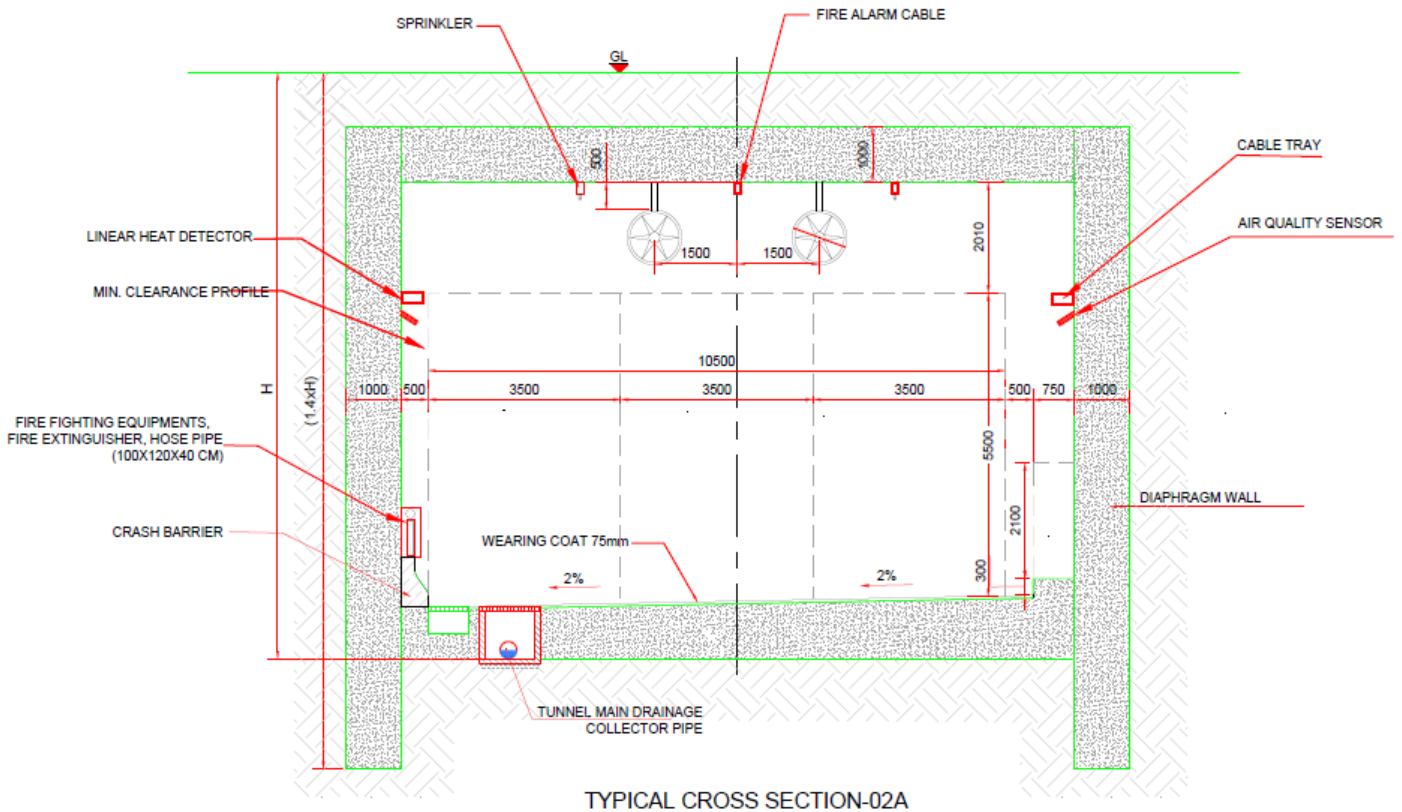
TYPICAL CROSS SECTION -02
CUT/COVER SECTION (3 LANES)
SCALE 1:50

NOTES:

1. ALL DIMENSIONS ARE IN mm.
2. THE STRUCTURAL DIMENSIONS SHOWN ARE INDICATIVE AND SUBJECTED TO CHANGE AS PER CONTRACTORS DETAILED DESIGN. DETAILED DESIGN OF LINING SHALL BE DONE BY CONTRACTOR.
3. SIZING AND DETAILS OF CRASH BARRIER, DRAINAGE , UTILITY PIPE TRENCH ETC . MAY CHANGE AS PER CONTRACTORS DETAILED DESIGN.
4. WALKWAY CAN BE PLANNED ON EITHER SIDE OF THE ROAD AS PER DETAILED DESIGN.
5. DRAWING SHALL BE READ IN CONJUNCTION WITH THE PROJECT SPECIFICATIONS AND CONTRACT PROVISIONS.

MATERIALS:

GRADE OF CONCRETE - M35
GRADE OF STEEL Fe550D

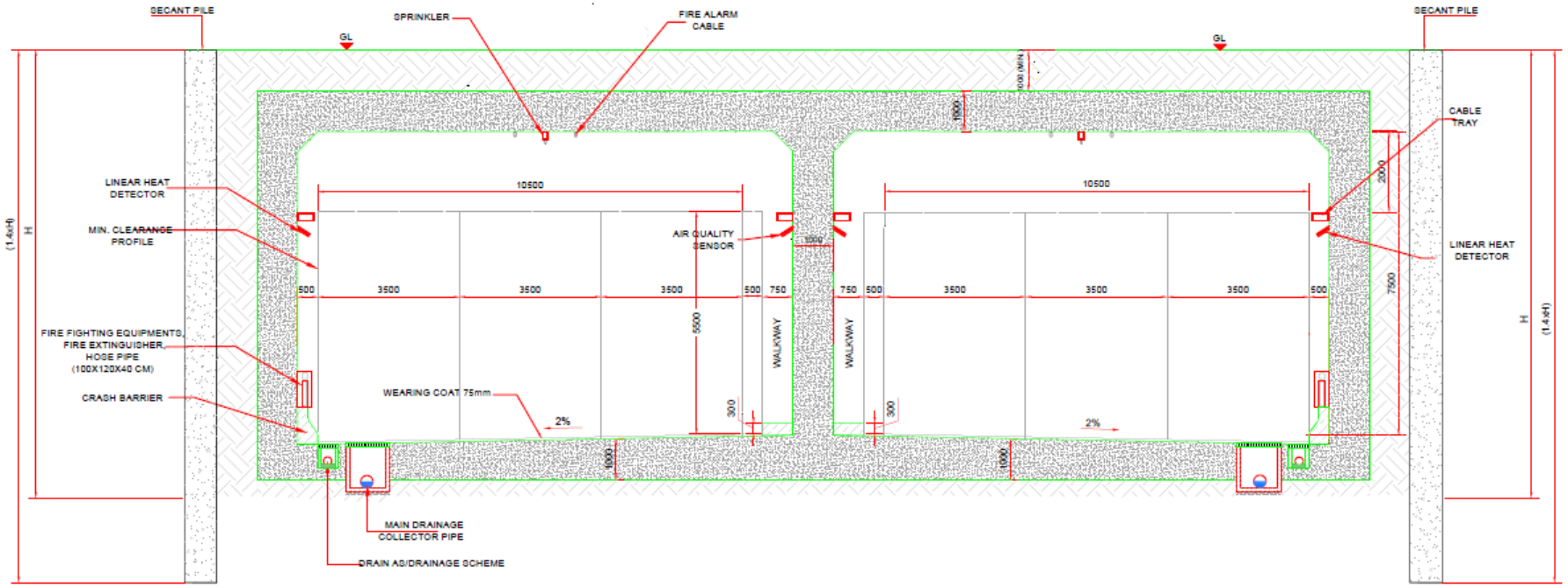


TYPICAL CROSS SECTION-02A
CUT/COVER SECTION (3LANE) WITH D WALL
SCALE 1:50

NOTES:

1. ALL DIMENSIONS ARE IN mm.
2. THE STRUCTURAL DIMENSIONS SHOWN ARE INDICATIVE AND SUBJECTED TO CHANGE AS PER CONTRACTORS DETAILED DESIGN. DETAILED DESIGN OF LINING SHALL BE DONE BY CONTRACTOR.
3. SIZING AND DETAILS OF CRASH BARRIER, DRAINAGE , UTILITY PIPE TRENCH ETC . MAY CHANGE AS PER CONTRACTORS DETAILED DESIGN.
4. WALKWAY CAN BE PLANNED ON EITHER SIDE OF THE ROAD AS PER DETAILED DESIGN.
5. DRAWING SHALL BE READ IN CONJUNCTION WITH THE PROJECT SPECIFICATIONS AND CONTRACT PROVISIONS.

MATERIALS:
GRADE OF CONCRETE - M35
GRADE OF STEEL Fe550D



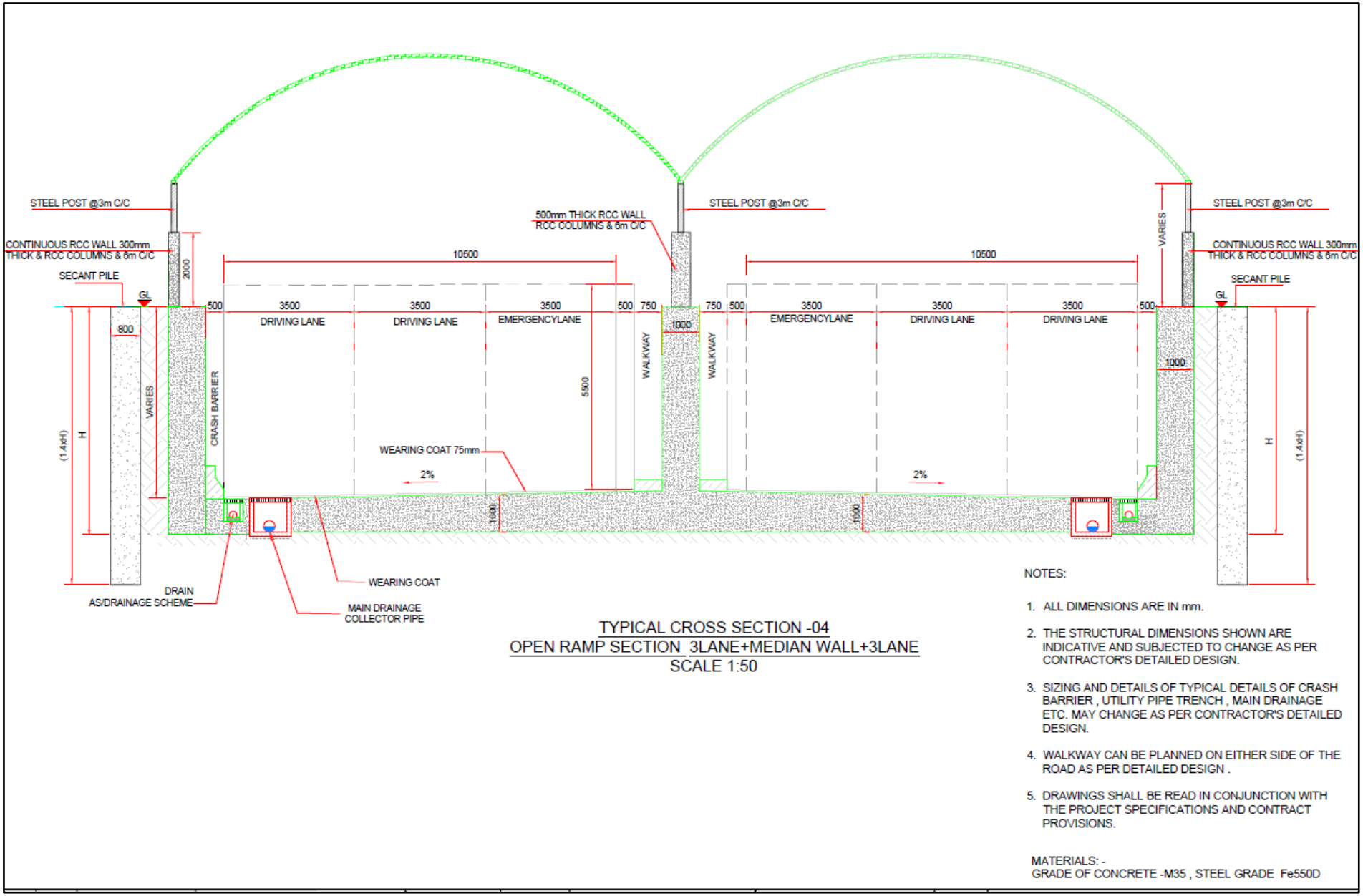
TYPICAL CROSS SECTION-03
CUT AND COVER (3 LANE+MEDIAN WALL+ 3 LANE)
SCALE 1:50

MATERIALS: -

GRADE OF CONCRETE -M35 ,
STEEL GRADE Fe550D

NOTES:

1. ALL DIMENSIONS ARE IN mm.
2. THE STRUCTURAL DIMENSIONS SHOWN ARE INDICATIVE AND SUBJECTED TO CHANGE AS PER CONTRACTOR'S DETAILED DESIGN.
3. SIZING AND DETAILS OF TYPICAL DETAILS OF CRASH BARRIER , UTILITY PIPE TRENCH , MAIN DRAINAGE ETC. MAY CHANGE AS PER CONTRACTOR'S DETAILED DESIGN.
4. WALKWAY CAN BE PLANNED ON EITHER SIDE OF THE ROAD AS PER DETAILED DESIGN .
5. DRAWINGS SHALL BE READ IN CONJUNCTION WITH THE PROJECT SPECIFICATIONS AND CONTRACT PROVISIONS.



TYPICAL CROSS SECTION -04
OPEN RAMP SECTION 3LANE+MEDIAN WALL+3LANE
SCALE 1:50

NOTES:

1. ALL DIMENSIONS ARE IN mm.
2. THE STRUCTURAL DIMENSIONS SHOWN ARE INDICATIVE AND SUBJECTED TO CHANGE AS PER CONTRACTOR'S DETAILED DESIGN.
3. SIZING AND DETAILS OF TYPICAL DETAILS OF CRASH BARRIER , UTILITY PIPE TRENCH , MAIN DRAINAGE ETC. MAY CHANGE AS PER CONTRACTOR'S DETAILED DESIGN.
4. WALKWAY CAN BE PLANNED ON EITHER SIDE OF THE ROAD AS PER DETAILED DESIGN .
5. DRAWINGS SHALL BE READ IN CONJUNCTION WITH THE PROJECT SPECIFICATIONS AND CONTRACT PROVISIONS.

MATERIALS: -
GRADE OF CONCRETE -M35 , STEEL GRADE Fe550D

Appendix B-II

Plan and Profile of Project

Will Insert Plan profle : It would make file heavy will attach once document is finalized.

Schedule - C

(See Clause 2.1)

Project Facilities

1. Project Facilities

The Contractor shall construct the Project Facilities in accordance with the provisions of this Agreement. Such Project Facilities shall include:

(a) roadside furniture;

i) Kilometer and Hectometer Board

i. Traffic Signs
ii. Overhead Signs
iii. Road Marking
iv. Road Delineators
v. Reflective Pavement Markers & Studs
vi. Traffic Impact Attenuators
vii. Boundary wall and Fencing
viii. Variable Message Sign

(b) Supervisory Control and Data Acquisition (SCADA) System Interfacing

(c) Lighting / illumination

(d) Environmental Management Plan

(e) Land Scaping and Tree Plantation

(f) Authority & Independent Engineers Offices

(g) Digital Tools for Project Monitoring

(h) Traffic Management System

(i) Logo on precast segments

(j) Art / Murals Work

(k) tree plantation;

(l) to be specified

2. Description of Project Facilities

Each of the Project Facilities is described below:

a. Roadside Furniture

The Road Furniture details provided in the Employer's Drawings are indicative. The road, Traffic and

Safety sign, marking drawings provided therein are for reference purposes and the Contractor shall design the sign and markings as per IRC 67, IRC 35, IRC: SP:85 and another relevant IRC and MoRT&H specification and get the same noticed by the Engineer.

b. Supervisory Control and Data Acquisition (SCADA) System Interfacing

The Contractor shall supply, test and commission the SCADA (Supervisory Control and Data Acquisition) system in this tunnel which will enable efficient monitoring and controls for various aspects of the tunnel's operations by interfacing with the E&M works that includes ventilation, lighting, traffic management, fire detection, and emergency systems, allowing operators to remotely manage the tunnel's functionality and respond to potential issues in real-time from a central control room located at shaft location. For detailed specifications refer **Schedule D**.

c. Lighting / Illumination

Illumination for overground sections shall be integrated with TICS (Tunnel Integrated Control System). The Tunnel Integrated Control System (TICS) shall serve as the centralized command and coordination platform for the entire tunnel infrastructur. Designed with a focus on safety, reliability, and automation, the TICS will enable real-time monitoring and intelligent control of all electro-mechanical, traffic, and safety systems within the tunnel and associated approach roads.

The TICS will integrate all critical subsystems including tunnel lighting (both normal and emergency), ventilation (jet fans and Saccardo systems), fire detection and suppression, CCTV surveillance with video analytics, public address and emergency call systems, variable message signs (VMS), lane control signals (LCS), environmental monitoring sensors (CO, NOx, visibility, temperature), power supply systems (HT/LT panels, UPS, DG sets), and automatic incident detection (AID). In addition, lighting for overground sections will be seamlessly integrated with TICS for unified operation and control.

The system shall be based on a distributed control architecture with a centralized SCADA (Supervisory Control and Data Acquisition) platform hosted in the Tunnel Control Room. The communication network will comprise a fiber-optic gigabit Ethernet backbone configured in a redundant ring topology, ensuring high availability and fault tolerance. All field devices shall interface via industrial-grade Programmable Logic Controllers (PLCs) or Remote Terminal Units (RTUs), allowing for reliable and scalable integration.

The SCADA software shall be modular, web-enabled, and based on an open architecture, capable of supporting real-time status displays, alarm management, system diagnostics, and event logging. Operators will interact through a graphical dashboard offering intuitive controls and visual representations of tunnel systems. Alarm management will include prioritized, color-coded alerts with real-time acknowledgments and logging. All system events will be timestamped and stored with a minimum archival capacity of one year. Access to the system shall be role-based, ensuring secure and controlled user permissions for operators, engineers, and administrators.

TICS will support standard communication protocols including Modbus TCP/IP, OPC UA, IEC 61850, SNMP, and ONVIF (for CCTV integration). It shall include strong cybersecurity features such as AES-256 encryption, firewall protection, intrusion detection, and full audit trails to ensure compliance with India’s data security regulations.

The system shall be engineered for high reliability, with a minimum availability of 99.95%. Redundancy shall be provided at multiple levels, including dual SCADA servers in hot-standby mode, dual LAN paths, and dual power supplies. Backup power shall be ensured through UPS (with a minimum 30-minute backup capacity) and diesel generator sets capable of supporting 100% operational load.

Environmental resilience will be achieved through equipment design and placement. Control room components will conform to IP41 protection standards, while field equipment will meet IP65 ratings.

The system will function across a temperature range of -10°C to +60°C and comply with EMI/EMC standards such as EN 61000.

To enable broader coordination, TICS shall be capable of integration with external platforms such as State/National Traffic Management Centers, Intelligent Transport Systems (ITS), and GPS/GNSS-based tolling systems.

In addition to automation and monitoring, the system shall support predictive maintenance by tracking equipment usage and performance trends, issuing early warnings for potential failures. Remote diagnostics and firmware upgrades will be enabled for field controllers to reduce downtime and manual interventions.

The Contractor shall also provide complete documentation including system architecture, operational manuals, and maintenance procedures, along with comprehensive training to designated operating staff. Training will cover SCADA operations, incident handling, and safety protocols.

In summary, the Tunnel Integrated Control System (TICS) shall serve as the intelligent nerve center of the tunnel infrastructure, offering a secure, automated, and scalable control environment aligned with modern ITS practices and national operational standards

d. Environmental Management Plan

The Contractor shall comply with the Environment Management Plan (EMP) including implementation and monitoring of mitigation measures suggested for the protection of environment during the construction and operation phase of the project.

e. Land Scaping and Tree Plantation

Land Scaping and Tree Plantation should be provided at Intermodal Hub locations at podium level and locations authorized by the Authority / Independent Engineer.

f. Authority & Independent Engineer's Offices

i. Office Spaces: The Contractor shall provide office spaces for the Authority and Independent Engineer with a minimum area of 500 sqm. during the construction period and a minimum area of 250 sqm. during the O&M period. The offices shall be complete with all fitting fixtures, lighting, furniture, and water supply, Internet Connection etc. The Contractor shall equip the conference hall in the office building with LCD screens as per the authority's requirement.

ii. The Contractor shall provide and maintain two vehicles (fuel driver and maintenance) during the Contract period for the Authority. The vehicle shall be brand new SUV approved by the Authority. The vehicle shall be available to the Authority at any time 7 days per week.

iii. The Employer and the Engineer shall designate a maximum of fifteen numbers of their computers for installation, by the Contractor, of software programs that the Contractor intends to use for document control, design, programming, production of drawings, etc. All software shall be originals and licensed by the manufacturer and issued and installed at the Contractor's cost.

g. Digital Tools for Project Monitoring

The Contractor shall design and commission the digital delivery system for effective information for all stages of the project development.

i. The system shall essentially comprise of Project Performance Management System (PPMS) which shall be duly integrated with the federated BIM model at appropriate Level of Detailing (LOD). Clients will have the final authority on deciding the PPMS to be implemented in this project. It will be a cloud-based system and should have the necessary accreditation/ empanelment from the relevant Ministry. PPMS should have functionality to support the distribution process i.e. transmittals and submittals. The system should have the ability to read and interface with CAD and BIM 3D model software.

ii. Building Information Modelling (BIM) be mandatorily utilized during the design, construction, operations, and maintenance stage. BIM shall be facilitated with due consideration to 3D modelling, designing, working drawing, information framework, supervision and approvals, quantity survey and approvals, project implementation planning, construction planning, construction material and vendor management, etc. The drawing shall be extracted from the federated 3D models developed by various stakeholders of the supply chain.

iii. The Contractor needs to ensure progress is updated in PPMS on a daily basis and related BIM model should also get updated. Based on "as built" drawing, "as built" BIM model should also be updated by Contractor.

The Contractor shall provide training to the Employer and any Engineer appointed by the Employer to enable them to make proper use of any software and training for any new version such as PPMS, BIM model and any other digital tools used in the Project.

h. Traffic Management

The Contractor shall plan his work in a manner to minimize disruption to road and the necessary care should be taken to divert the vehicle through the diversion road during construction, during muck dumping and during excavation work at the project site. The Contractor shall prepare a traffic management plan (based on his proposed construction methodology) which need to be approved by the Engineer and concerned Traffic Police Offices including Interfacing Contractor for the other package in the same project. To facilitate the proper traffic movement temporary road diversion, and temporary road decking shall be provided wherever necessary.

i. Logo

BDA logo at a minimum of 5% segments is required.

j. Art / Murals Work

A minimum total Area of murals/Artwork around 600 sqm shall be provided.

Artwork is to be provided in the form of indoor sculpture / outdoor sculpture, Wall Murals, Glass mosaic tile and cut-glass mosaic etc. on all the entry-exits of Project Tunnel. The Contractor shall prepare specifications, methodology, sketches, 3D models etc. and any other relevant details and get approval of the Authority before execution.

Artwork with Glass Mosaic Tiles

1. Glass Mosaic Tiles

Tiles shall be composed of 100% glass, sourced from soda-lime, silica, or recycled glass material. The material must be non-porous, non-reactive, and stable under UV and moisture exposure (particularly for outdoor or wet-area applications). Standard size of tiles shall range from 12mm x 12mm to 50mm x 50mm. Thickness of the tiles typically ranges between 3mm and 6mm. Custom art works may use thicker glass tiles for 3D-effects. Tolerance on dimensions should not exceed ±0.5mm to ensure consistent grout joint spacing.

The tile finish can be glossy/clear for depth and brilliance, matte/frosted for muted, soft appearances; Iridescent for light-reflective and color-shifting effects; and Textured/Patterned for tactile surface effects or light diffusion, as approved by Authority Engineer.All finishes should be scratch-resistant and maintain integrity under cleaning.

Tile edges may be straight cut for tight, uniform spacing, tumbled or rounded for a weathered, antique look, edge sharpness should be mitigated to ensure safety during installation and final display.

Glass tiles must be UV-resistant with stable pigments or colored substrate. Color variation should be controlled within manufacturer-specified tolerance. For custom artwork, artists may use hand-colored or fused-glass tiles, if approved by Independent Engineer.

2. Substrate and Backing Systems

Interior Walls: Cement board, plaster, or properly sealed drywall. Interior Floors: Plywood (underlayment grade), concrete slab, or cementitious backer board. Exterior Applications: Concrete, cement board, or brick walls with waterproof membranes. Sculptural substrates: Polystyrene coated in fiberglass mesh and mortar; or shaped concrete panels. Substrates must be clean and free of dust, grease, or efflorescence, Flat within 3mm over 3metre for proper adhesion. Primed or sealed if porous or moisture sensitive.

Mounting Systems shall be paper-faced tiles (face-mounted): Provide clean grout lines and are recommended for wet areas, mesh-backed tiles: Easier to handle but must be tested for adhesive compatibility or dot-mounted or film-faced tiles may be used for temporary positioning during dry fitting. For artisan work, individual hand-placement (unglued, direct method) allows the highest detail.

3. Adhesives and Mortar –

White polymer-modified thin-set mortar (ANSI A118.4 or A118.15 compliant). Color: White is preferred to prevent shadowing through transparent or light-colored glass. The mortar should have high bond strength, flexibility for thermal expansion and contraction and non-sag for vertical applications. The mortar shall be applied using a 3mm V-notch trowel for even distribution, using the "back-buttering" technique on large or uneven tiles and the open time should not exceed 20–30 minutes; the tiles should set within working time. The tile work shall be cured for at least 24–48 hours before grouting, depending on temperature and humidity.

4. Grouting:

Grout for the glass mosaic tiles can be unsanded grout for joints ≤ 3mm; avoids scratching glass, sanded grout for joints > 1/8", provided tiles are not easily scratched or epoxy grout (ANSI A118.3), use of particular grout shall be selected and approved by Independent Engineer considering high-moisture or commercial areas due to superior strength, stain resistance, and water impermeability. Joint width shall be 1.5mm to 3mm consistent spacing is crucial for aesthetic balance and structural integrity. Grout Application shall be pressed into joints using a rubber float, holding it at a 45° angle. The surface shall be cleaned with damp sponge within 10–15 minutes to avoid hazing. For glass tiles with a textured or grooved surface, pre-sealing or masking shall be done. Glass tiles generally do not require sealing, subject to manufacturer's specifications. For sealing penetrating sealer shall be used on grout joints in case of cementitious grout.

5. Finishing and Framing

Complementary or contrasting border tiles to frame the mosaic artwork. For wall art or installations, aluminum or stainless-steel trim profiles shall be used as approved by Authority Engineer.For standalone artworks rigid framing shall be provided with reinforced back panels. For murals, edge protectors shall be incorporated if exposed to traffic or abrasion. Protective Measures material shall be covered with foam or non-abrasive material during transportation and after installation tiles shall be cleaned with pH-neutral cleaner, acids, alkalis, or abrasives shall be avoided.

6. Artistic and Design Considerations

Artwork shall be developed at full scale or created a to-scale template. Software like Mosaic Creator, Adobe Illustrator, or CAD may be used for layout planning. For large works, modular sections shall be created for easier installation.

Consider how natural or artificial light interacts with transparent or iridescent tiles. Blend similar tones for gradients; use contrasting tiles for emphasis or outlines. Use wheeled mosaic nippers for curves and shaping. For precision cuts, a glass score-and-break system or wet saw with glass blades are ideal. Always smooth sharp edges using a glass stone or diamond pad.

7. Safety and Environmental Considerations

The workers shall wear cut-resistant gloves and safety goggles during cutting, they will use dust masks when dry cutting or sanding backing boards. Proper ventilation shall be ensured when using

adhesives or epoxy and the workspace shall be kept clean and organized to prevent injury from glass shards. The sharp tile fragments shall be collected and safely disposed of in puncture-proof containers.

k. Tree Plantation as per state guidelines.

Schedule D

Annex – I

Specifications and applicable standards for construction of Cut-and-Cover Tunnels, Underground Ramps, associated underground and above-ground structures, at-grade roads, and all related systems.

Section 1

Specification and Standards

1.1 Preamble

This section covers Construction Specifications for Roads and should be read in conjunction with all other Documents constituting the Contract – viz. Invitation for Bids (NIT), Instructions to Tenderers, Conditions of Contract, Design Specifications, Construction Specifications, Drawings and other related documents. These Specifications given herein apply for elements of Road and Road structures.

1.2 Site Information

The information given hereunder and provided elsewhere in these documents is given in good faith by the Authority, but the Contractor shall satisfy himself regarding all aspects of site conditions and no claim will be entertained on the plea that the information supplied by the Authority is erroneous or insufficient.

The area in which the work is located is in plain/rolling terrain and lies in the city limits of Bengaluru.

1.3 General Climatic Conditions

a) Bengaluru has an equable climate throughout the year with occasional extreme weather events like heatwaves, cold waves, floods and droughts. The highest temperature ever recorded in Bengaluru is 41.8°c on April 30, 2024 in Kengeri at Bengaluru.

b) The hottest summer day on average has a maximum temperature of about 37°c, and the coldest winter day has a temperature of about 13°c. Occasionally, heat waves can cause temperatures of up to 38-40°c. Occasional cold waves will be leading to the temperatures as low as below 9-10°c. Bengaluru receives about 970 mm of rain annually, with the wettest months being August, September and October. The heaviest rainfall recorded in a 24-hour period was 18 cm recorded on 1988.

1.4 Manual of specifications and standards to apply

All materials, works and construction operation shall conform to the Manuals of Specifications and Standards IRC SP 87-2019, IRC:86-2018, IRC: SP: 91-2019, IRC: SP: 118-2018, Published by IRC (referred to as “Manuals” in this Schedule) and MoRTH Specification for Road and Bridge Works.

1.5 Deviations from the Manual

Notwithstanding anything to the contrary contained in Paragraph 1.1 to 1.4 above, the following Specifications and Standards shall apply to the Project Road and for purposes of this Agreement, the aforesaid Specifications and Standards shall be deemed to be amended to the extent set forth in sections hereinafter.

1.6 Codes and Standards

Table 1.1 References to the Standard Codes of Practice from:

MORTH	Ministry of Road Transport and Highways
IRC	Indian Road Congress
ASCE	American Society of Civil Authority Engineer s
ASME	American Society of Mechanical Authority Engineer s
ASTM	American Society for Testing Materials
BS	British Standard
CPWD	Central Public Works Department
DIN	Deutsches Institut für Normung e.V.
IRC	Indian Road Congress
IRCEM	Institution de Retraite Complementarie des Employes de
	Particular
IRS	Indian Railway Standards

IS	Indian Standards
MORTH	Ministry of Road Transport and Highways
UIC	International Union of Railways

Table 1.2 Applicable Codes, Standards & Publications

Code No.	Title
IS 875 Part I	Dead Loads - Unit weights of building Materials and stored materials.
IS 875 Part II	Imposed loads
IS 875 Part III	Wind Loads
IS 875 Part IV	Special Loads and Combinations
IRC:6	Standard Specifications and Code of Practice for Road Bridges
IRC:16	Standard Specification and code of Practice for Prime and Tack Coat (Second Revision)
IRC:19	Standard Specification and code of Practice for Water Bound Macadam (Third Revision)
IRC: 35	Code of Practice for Road Markings
IRC:37	Guidelines for the Design of Flexible Pavements
IRC:38	Guidelines for Design of Horizontal Curves for Highways and Design Tables
IRC:58	Guidelines for the Design of Rigid Pavements for Highways
IRC:67	Code of Practice for Road Signs
IRC:69	Space standards for Roads in Urban areas
IRC:70	Guidelines on Regulation and Control of Mixed Traffic in Urban Areas
IRC:86	Geometric design standards for urban roads and streets
IRC:92	Guideline for Design of Interchanges in Urban areas
IRC:93	Guidelines on Design and Installation of Road Traffic Signals
IRC:98	Guidelines on accommodation of Utility Services in Urban Areas
IRC:102	Traffic Studies for Planning Bypasses around Towns
IRC:103	Guidelines for Pedestrian Facilities
IRC:106	Guidelines for Capacity of Urban Roads in Plain Areas
IRC: SP:23	Vertical curves for Highways
IRC: SP:41	Guidelines on Design of At-Grade Intersections in Rural and Urban Areas
IRC: SP:42	Guidelines on Road Drainage
IRC: SP:43	Guidelines on Low-cost Traffic Management Techniques for Urban Areas
IRC: SP:49	Guidelines for the Use of Dry Lean Concrete as Sub-base for Rigid Pavement
IRC: SP:50	Guidelines on Urban Drainage
IRC: SP:61	An Approach Document on Whole Life Costing for Bridges in India
IRC: SP:63	Guidelines for the Use of Interlocking Concrete Block Pavement
IRC: SP-87	Manual of Specifications & Standards for Six Laning of Highways Through Public Private Partnership.
IRC: SP:88	Manual on Road Safety Audit
IRC: SP:92	Guidelines for the Design of Interchange in Urban Areas
IRC: SP:112	Manual for Quality Control in Road and Bridge works
IRC: SP:118	Manual for Planning and Development of Urban Roads and Streets
	CODES OF DESIGN AND FABRICATION FOR PRE - AUTHORITY ENGINEER ED BUILDING
IS 800: 2007	General construction in steel
IS 808: 1989	Dimensions for hot Rolled steel sections
IS 801 : 1975	Code of Practice for use of Cold Formed light gauge steel structural members in general building
IS 811	Code of Practice for use of Cold Formed light gauge structural steel sections
AISC: 2000	Design code
IBC	Indian Building code
AISI:2001	Purlin Code
ANS:2006	Welding Code
SP-38: (S&T)	Handbook of typified designs for structures with steel Roof Code

IS 816	Code of Practice for use of metal arc welding for general ·- construction in mild steel
IS 456	Plain and Reinforced Concrete Code of Practice
IS 1893	Criteria for Earthquake resistant design of structures
IS 6403	Code of Practice for determination of bearing capacity of shallow foundations
IS 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement
IS 13920	Code of practice for ductile detailing of reinforced concrete Structures subjected to seismic forces
SP-16	Design aids for reinforced concrete to IS 456.
SP-34	Handbook on concrete reinforcement and detailing
	All relevant BIS Code of India for Civil, Electrical, Water Supply, Sanitary, HVAC and Solar Panels.
SP-35	Handbook of Water Supply and Drainage, BIS,

1.7 Deviations from the Manual and Codes

Deviations needed to be updated.

Sl No.	Clause referred in manual	Item	Modified Provision
1	2.5	Median	As per typical cross section given in Schedule-B.
2	2.6	Shoulders	As per typical cross section given in Schedule-B.
3	2.16	Utility Corridor	Utility corridor width shall be as per typical cross section given in Schedule-B
4	2.17	Typical Cross – Section	Typical cross section shall be as per Schedule-B.
5	Clause 2.e of Appendix-B of IRC:SP:91-2019	Footpath	One footpath of 750 mm wide and raised 340 mm from road level is to be provided.

1.8 The work shall include but not be limited to:

a) Survey and Setting out of the Alignment

b) Additional Exploratory Geotechnical Investigations along the alignment of the tunnels and cut and cover portions etc., if necessary,

c) Excavation of Open Cuts in all types of soils and rock including provision of treatment such as Soil Nailing, Rock bolting, Installation of Wire Netting, Shotcreting, grouting etc. to the excavated profile as and where necessary as per approved design, drawings and as directed by the Authority Engineer.

d) Tunnel Excavation in all types of soils and rock as and where necessary as per approved design, drawings and as directed by the Authority Engineer.

e) Construction of Cut & Cover Portion and Concrete Portals with Backfill behind with drainage arrangements, in the Approach Cuts.

g) Concrete side Drains/ cover Drains, Kerbs and Crash Barrier etc. in the Tunnels, Cut & Cover Portions and Open Cuts.

h) Installation of Furnishings such as Walkway Slabs, Hand Railing for the Walkways, Fire Water Line etc. in the Tunnels, Cut & Cover Portions and Open Cuts.

i) Design, Supply, Erection, Testing and Commissioning of Mechanical, Electrical and Plumbing Services.

Section 2

Road Works

2.1 MORTH Specifications for Road Works

a) The General Technical Specifications for Road works shall be the "Specifications for Road and Bridge Works" (Fifth Revision, 2013) issued by the Ministry of Road Transport and Highways, (MoRTH), Government of India, and published by the Indian Roads Congress (IRC). Latest editions with corrections and amendments up to date to the extent they are applicable to the Road works covered under scope of works. Further the specifications for Road works contained herein for some of the items of work will supersede the provisions of the MORTH Specifications for Road works to the extent of their applicability.

b) Where reference is made in the Contract to specific standards codes to be met by the materials, plant, and other supplies to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards as on date of tender and codes in effect shall apply, unless otherwise expressly stated in the Contract. Where such standards and codes are national, or relate to a particular country or region, other internationally recognized standards which ensure a substantially equal or higher performance than the standards and codes specified will be accepted subject to the Authority Engineer 's prior review and written Notice. The difference between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Authority Engineer at least 28 days prior to the date when the Contractor desires the Authority Engineer 's Notice. In the event the determines that such proposed deviations do not ensure substantially equal performance, the Contractor shall comply with the standards specified in the documents.

2.2 Amendments/Modifications/Additions to Existing Clauses of General Technical Specifications.

a) The amendments to General Technical Specifications for Road works shall comprise of various Amendments/Modifications/Additions to the "Specifications for Road and Bridge Works" referred to in Para 2.1 above and Additional Specifications for particular item of Road works not already covered in General Technical Specifications.

b) A particular Clause or a part thereof in "Specifications for Road and Bridge Works (Fifth Revision, 2013)", as corrected in the original referred in Para 2.1 above, where Amended/Modified/Added upon, and incorporated, such Amendment/ Modification/ Addition supersedes the relevant Clause or part of the Clause.

c) The Additional Specifications shall comprise specifications for particular items of work not already covered in General Technical Specification.

d) When an Amended/Modified/Added Clause supersedes a Clause or part thereof in the said Specifications, then any reference to the superseded Clause shall be deemed to refer to the Amended/Modified/Added Clause or part thereof.

Concrete Plant Operation

a) The batch plant can be a commercial concrete batch plant, or a temporary batch plant brought in and assembled by the Contractor near the paving site. On large concrete paving projects, most Contractor choose to mix their concrete using their own temporary batch plant. This is because commercial batch plants are usually too small to produce the large amount of concrete needed for a concrete paving project.

b) All batching of materials shall be by weight. After determining the proportion of ingredients for the field mix, the fine aggregate and each separated size of coarse aggregate shall be proportioned by weight in an approved weigh-batching plant and placed into the hopper of the mixer along with the necessary quantity of cement.

c) Cement shall be measured either by weight or by the bag as packed by the manufacturer. Where cement is measured by the bag, it is necessary to sample check the weight of the bags

occasionally. All materials other than cement shall be calculated based on one or more whole bags of cement taking the weight of cement as 1440 kg/cu.m. Water may be measured by volume. Where it is unavoidable, volume batching of aggregates may be permitted as a special case in small projects.

d) The batching plant/concrete mixer shall be capable of proportioning the materials by weight, each type of material being weighed separately. The capacity of the batching and mixing shall be at least 25 percent higher than the proposed capacity for the laying arrangements. The rated capacity of the mixer shall not be less than 0.3 cum. The weighing mechanism shall be checked periodically and calibrated, to yield an accuracy of ± 2 percent in the case of aggregates and ± 1 percent in the case of cement, fly ash and water. When fly ash is added, the mixing time shall be increased by a minute to ensure proper mixing.

e) The mixing speed of the drum shall not be less than 15 revolutions per minute nor the peripheral speed of the drum greater than 60 m per minute. The sequence of loading shall be coarse aggregates, fine aggregates, cement, fly ash if used. After mixing dry, water will be released from the venturi meter.

1. Hauling of mix

a) The mix shall be discharged immediately from the mixer, transported directly using wheelbarrows or tippers to the point where it is to be laid and protected from the weather by covering with tarpaulin during transit.

b) Transportation of concrete mix from mixer to paving site with steel pans is not permitted in major works as the mix tends to get segregated during such handling. It is desirable to use wheelbarrows or trolleys for carrying mix to the paving site. The workability of the mix can be controlled better with the use of wheelbarrows.

c) The concrete shall be transported continuously to feed the laying equipment to work at a uniform speed in an uninterrupted manner.

2. Equipment

a) The concrete shall be placed with an approved fixed form or slip form paver with independent units designed to (i) spread, (ii) consolidate from the mould, screed and float-finish, (iii) texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary and so as to provide a dense and homogeneous pavement in conformity with the plans and Specifications.

3. Placing Concrete

a) Concrete shall be deposited on the sub-base to the required depth and width in successive batches and in continuous operation. Care shall be taken to see that no segregation of materials results.

b) Concrete shall be placed within one hour of the time of batching and before it has attained initial set. The temperature of the concrete when deposited in the forms shall be not less than 10°C or more than 30°C. Concrete shall not be placed either during rain or when the air temperature in the shade is below 5°C or above 35°C.

c) The placing and spreading shall be done by a paver. While being placed, the concrete shall be rodded with suitable tools so that the formation of voids or honeycomb pockets is avoided. In case of unavoidable interruption, a full depth transverse joint shall be made at the point of stoppage of work provided the section on which the work has been suspended is about 2 to 3 m long.

4. Compaction

a) The compaction shall be carried out immediately after the material is laid with the necessary surcharge (extra loose thickness) and leveled. The spreading, compacting and finishing of the concrete shall be carried out as rapidly as possible and the operation shall be so arranged as to ensure that the time between the mixing of the first batch of concrete in any transverse section of the layer and the final finishing of the same shall not exceed 90 minutes when the

concrete temperature is above 25 and below 30°C and 120 minutes if less than 25°C.

b) Compaction shall be achieved by a vibrating hand screed. As soon as concrete is placed, it shall be struck off uniformly and screeded to the cross-section desired. Needle vibrators may be employed to ensure compaction near the forms. The entire surface shall then be vibrated with screed resting on the side forms and being drawn ahead with a sawing motion, in combination with a series of lifts and drops alternating with lateral shifts. Working of the vibrators shall be regularly checked and stand by shall always be maintained for emergency use. Segregated particles of coarse aggregate which collect in front of the screed shall be discarded. Under no circumstances shall such segregated particles be carried forward and pushed on to the base in front of the mass.

c) Immediately after the screeding has been completed and before the concrete has hardened, i.e. while the concrete is still in the plastic stage, the surface shall be inspected for irregularities with a profile checking template and any needed correction made by adding or removing concrete followed by further compaction and finishing.

d) After compaction has been completed, roller shall not stand on the compacted surface for the duration of the curing period except during commencement of next day's work near the location where work was terminated the previous day.

5. Finishing

a) In the case of normal concrete just before the concrete becomes non-plastic, the surface shall be belted with a two-ply canvas belt not less than 200 mm wide and at least 1 .0 m longer than the width of the slab. Hand belts shall have suitable handles to permit controlled uniform manipulation. The belt shall be operated with short strokes transverse to the carriageway centerline and with a rapid advance parallel to the centerline.

b) After belting, and as soon as surplus water, if any, has risen to the surface, the pavement shall be given a broom finish with an approved clean steel or fiber broom not less than 450mm wide. The broom shall be pulled gently over the surface of the pavement from edge to edge.

c) Adjacent strokes shall be slightly overlapped. Brooming shall be perpendicular to the centerline of the pavement and so executed that the corrugations thus produced shall be uniform in character and width, and not more than 1.5 mm deep. Brooming shall be completed before the concrete reaches such a stage that the surface is likely to be torn or unduly roughened by the operation. The broomed surface shall be free from porous or rough spots, irregularities, depressions, and small pockets, such as, may be caused by accidentally disturbing particles of coarse aggregate embodied near the surface.

d) After belting and brooming have been completed, but before the concrete has taken its initial set, the edges of the slab shall be carefully finished with an edge tool of 6 mm radius, and the pavement edge left smooth and true to line.

6. Curing of Concrete

A. Immediately after the finishing operations have been completed, the entire surface of the newly laid concrete shall be covered against rapid drying and cured. Curing can be done by one of the following two methods:

   a) By application of curing compound followed by spreading of wet hessian and moistening it regularly. In case of arid areas where water is extremely scarce, two applications of curing compound with moist curing by wet hessian may be allowed at the discretion of the Authority Engineer. Curing compound shall be resin based aluminized reflective type.

   b) For small works, curing can be done by manual methods using wet hessian/ burlap or jute mats, which is kept moist during curing period. Curing shall be done for a minimum period of 14 days. In case of blended cement curing shall be done for 16 days. The water used for curing shall also be free from all injurious chemicals, like, chlorides and sulphates and shall meet the requirements of IS 456.

   c) After the concrete has begun to harden i.e. about 1 to 2 hours after it's laying, it shall be

protected from quick drying with moist gunny bags, sand or any other material approved by the Authority Engineer. After 24 hours of laying of concrete, the surface shall be cured by flooding with water of minimum 25mm depth, or by covering with wet absorbent material i.e. wet hessian cloth (minimum of two layers), burlap or jute mats.

d) The coverings used shall be of such length (or width) that when laid will extend at least 500 mm beyond the edges of the slab, shall be so placed that the entire surface and placed as soon as the concrete has set sufficiently to prevent marring of the surface. Prior to their being placed, the coverings shall be thoroughly wetted with water and placed with the wettest side down. They shall be sufficiently heavy so as to cause them to remain in intimate contact with the surface covered. They shall be maintained fully wetted and in position for 24 hours after the concrete has been placed, or until the concrete is sufficiently hard to be walked upon without suffering any damage.

e) To maintain the coverings wet, water shall be gently spayed so as to avoid damage to the fresh concrete. If it becomes necessary to remove the coverings for cutting the joints, the concrete slab shall not be kept exposed for a period of more than half an hour. The rate of evaporation of water from the PQC shall not be more than 1 kg/sq. m/hour to avoid plastic shrinkage cracking. Water curing shall be done for a minimum period of 14 days.

f) Worn coverings or coverings with holes shall not be permitted. If the covering is furnished in strips, the strip shall be laid to overlap at least 150 mm.

g) Walking on freshly laid concrete to facilitate placing coverings or any other use which could be otherwise done without using the freshly laid concrete at least up to 28 days will not be permitted to maintain the texture depth provided.

7. Removal of Formwork

a) Forms shall be removed only after the concrete has set for at least 12 hours. They shall be carefully removed without causing damage to the edge of the pavement. After the removal of forms, the ends shall be cleaned and any honey-combed areas pointed with 1:2 cement- sand mortar, after which the sides of the slab shall be covered with earth to the level of the slab. In case the adjoining soil has more than 0.5 percent sulphates, the sides may be painted with a bituminous tack coat.

8. Protection of Concrete

a) The freshly laid concrete shall be protected by suitable barricades to exclude traffic. No heavy commercial vehicles carrying construction materials shall be allowed for a period of 28days. Tractor trailers without any construction materials and light commercial vehicles may be allowed after 14 days.

b) Any part of the pavement damaged by traffic or other causes occurring prior to its final acceptance shall be repaired or replaced in a manner satisfactory to the Authority Engineer.

9. **Joint Cutting:** The Joints of the Rigid pavement shall be designed & constructed as per IRC:58-2015 and as approved by Authority Engineer.

B. **Cement Concrete Wearing Coat:** Cement concrete wearing coat shall be laid separately over the Tunnel slab. The cement concrete wearing coat shall be designed for design traffic load. The minimum thickness of wearing a coat shall be 75 mm. The concrete shall be of minimum M30 grade. Steel reinforcement of 8 mm diameter at 150 mm spacing in both directions shall be provided at the mid depth of the wearing coat. In a length of 1 m near the expansion joint additional reinforcement of 8 mm diameter bars shall be provided in both directions to make the spacing as 75 mm. Cement concrete and steel reinforcement shall conform to Section 1700 and Section 1600 respectively of MoRTH Specifications:2013. Curing of wearing coat shall start as early as possible. All carriageway and footpath surfaces shall have non-skid characteristics. The cross slope in the deck shall be kept as 2.5 percent. In case of cement concrete wearing coat provide profile corrective course along with wearing coat in single

layer.

Overlay on the existing wearing coat on bridge decks shall not be permitted. In case the wearing coat is damaged, it shall be repaired or replaced.

C. Construction of Flexible Pavement

1. Setting Out

a. All construction shall be done with reference to the final centerline of the main location survey. The centerline should be accurately referenced, every 50m interval in plain and rolling terrains, 20 m intervals in hilly terrains and at all curve points, by marker pegs and chainage boards set in or near the fence line. The schedule of reference dimensions shall be prepared, and marker pegs shall be maintained till the end of the work. Working benchmarks tied with the reference benchmark should be established at the rate of four numbers per km and at or near all drainage structures, other bridge and underpasses. An up-to-date record of all benchmarks shall be maintained, and the working benchmarks should be checked frequently.

b. On construction reaching the formation level stage, the centerline should again be set out and accurately referenced by marker pegs at the outer limits of the formation. Posts of timber or steel should be kept one metre from the formation edges showing the finished formation/ finished base course/finished road levels. It should be possible to stretch a thread across to verify the finished levels of various courses. All survey monuments, benchmarks, beacons, etc. should be maintained accurately during the construction process. A survey file containing the setting out data for traverse points and levels shall be prepared and maintained during the construction process.

c. Precision automatic levels, having a standard deviation of ± 2 mm per km and fitted with micrometer attachment shall be used for all double run levelling work. Setting out of the road alignment and measurement of angles shall be done by using Total Station with traversing target, having an accuracy of one second. Measurement of distances shall be done preferably using precision instruments like Distomat. The work should conform to Clause 109 of MORTH Specifications for Road and Bridge Works.

2. Earthwork

a. Excavation for Roadway and Drainage - All materials in excavation are to be classified as one of the following:

1. Soil Ordinary rock (not requiring blasting)
2. Hard rock (requiring blasting)
3. Hard rock (blasting prohibited) and marshy soil.

This classification is based on the methods, tools and equipment required for excavation.

b. The area for the roadway and drainage excavation should be cleared and grabbed. Set out the limits of excavation true to lines, curve, slopes and grades and sections as shown on the drawings. Periodicals checks are to be done on the benchmarks and on the construction lines for accuracy. The work shall be so done that the suitable materials available from excavation are satisfactorily utilized as deemed fit. All reasonable precautions are to be taken for protection and preservation of any or all existing trees, drains, sewers, sub-surface drains, pipes, conduits, or any other structures which may be affected by construction operations. All adequate precautions are to be taken to guard against soil erosion, water pollution etc. and appropriate drainage measures are also to be taken. If water is met with in the excavation, it shall be removed by suitable diversions, pumping or bailing out and the excavation is to be kept dry.

c. Preparation of cut formation

1) Cut formation requires very close inspection for the reason that it is for the first time that the material gets exposed. Check the suitability of the natural material. Some shale may look hard when dry but get slushy in presence of water. If such unsuitable materials

are met with, have these removed to a depth of at least 0.5 m or as otherwise specified and replaced with suitable material. If density of sub-grade is lower than specified density, it shall be loosened to a depth of 500 mm, recompacted in layers not less than 97 per cent of the maximum laboratory dry density as per clause 9.5.6. In rock formation all dish shaped cavities left out by blasting should be cut out at edges to facilitate drainage. Low areas should be filled up with sub-base material and properly compacted. Any seepage should be intercepted and properly drained. Earth work for excavation shall be carried out as per clause 301 of MORTH Specifications for Road and Bridge works.

d. **Excavation for Structures** - The points which require specific attention in excavation work are:

1) Setting out be true to lines, curves, slopes and levels.

2) Excavation shall be taken to the width of the lowest step of the footing including additional width as required for construction operation. The depth to which the excavation is to be carried shall be as shown in the drawing. Normally, open foundations shall be laid dry. Dewatering by bailing, pumping, diversion channels and other necessary works should be carried out when seepage flow is met with. Where cofferdams are required, these are to be safely designed and made watertight and should be carried to adequate depth and heights.

3) The discharged water should not cause damage to the works, crops, or any other property.

4) Backfilling shall be done with approved material after concrete or masonry is fully set. The backfilling is to be done upto the original surface in layers not exceeding 150 mm compacted thickness to be compacted with the help of suitable equipment such as trench compactor, mechanical tamper, rammer plate vibrator etc.

5) The work shall be carried out as per Clause 304 of MORTH Specifications for Road and Bridge Works.

e. Embankment and Subgrade Construction

1) This work also involves construction of subgrades, earthen shoulders and miscellaneous backfills in addition to the construction of embankment for accommodating the roadway. The materials used for this work shall be soil, moorum, gravel, reclaimed material for pavement, fly ash, pond ash, a mixture of these. Materials from swamps, marshes and bogs, peat, logs stump, perishable material, any soil classified as OL, OI, OH or Pt, material susceptible to spontaneous combustion, materials in frozen condition, clay with liquid limit exceeding 50 and plasticity index exceeding 25 and materials with salts resulting in leaching in the embankment should be considered unsuitable material for embankment.

2) Permit delivery of embankment material to site only if the necessary rollers in working condition are present at site. Have a special check on the following points during the construction operations:

i) Before starting the construction operation, the site should be cleared and grubbed. The limits of the embankment/ sub-grade should be marked by fixing batter pegs on both sides at regular intervals. The embankment should be built sufficiently wider than the designed dimension so that surplus material may be trimmed.

ii) If the foundation of embankment is in area with stagnant water, the same should be removed by bailing out or pumping and should be kept dry. The drain water discharge should not cause damage to the works, crops, or any other property.

iii) All areas covered by embankment foundation shall be stripped to specified depths, not exceeding 150 mm, and stored in stockpiles of height not existing 2 m for covering embankment slopes.

iv) The soil delivered at site must be obtained from approved sources. The guidelines

and environmental requirements, in respect of excavation and borrow areas as stipulated from time to time by MOEF and local bodies, are to be strictly followed by the Contractor.

v) Reserve better of the available fill material for the top 500 mm of the embankment and shoulders. If heavy clays have to be used, have these deposited in the bottom layers.

vi) Clods or hard lumps of earth should be broken down. The size of clods should not exceed 75 mm when placed in body of embankment and 50 cm when placed in subgrade portion.

vii) Static three wheeled roller, self-propelled single drum vibrator roller, tandem vibratory roller, pneumatic tyre roller pad foot roller etc. of suitable size and capacity shall be used for the different types and grades of materials required to be compacted either individually or in suitable combination.

viii) The embankment and subgrade material shall be spread in layers of uniform thickness over the entire width of embankment by a motor grader. The compacted thickness of each layer shall not be more than 250 mm. The compacted thickness of each layer shall not be more than 200 mm when static roller is used. Successive layers shall not be placed until the layer under construction has been thoroughly compacted to the specified requirements. Compacted layer shall be finished parallel to the final cross- section of the embankment.

ix) Subgrade can be made up of in-situ material, select soil, or stabilized soil forming the foundation for the pavement. It should be well compacted to derive optimal strength and to limit the rutting caused due to additional densification of the layer during service life. When the subgrade is formed using a material which is stronger than the upper 500 mm of embankment soil or when the subgrade itself is prepared in two separate layers with significantly different strengths, the effective combined contribution of the subgrade and the embankment layers has to be considered for design. A sub grade CBR value of 8 % has been considered for the design of pavement. Sub grade is to be compacted with minimum of 98 % of maximum dry density of modified proctor compaction tests.

Table 2.2: Compaction requirement of Embankment and Subgrade

Sl. No.	Type of work	Relative compaction as percentage of maximum laboratory dry density as per IS:2720 (Part 8)
1	Subgrade and earthen shoulders	Not less than 97%
2	Embankment	Not less than 95%
3	Expansive Clays	a) Subgrade and 500 mm portion just below the subgrade - -Not allowed b) Remaining portion of embankment - 90-95%

x) Moisture content of the soil shall be checked and corrected at the site of placement prior to commencement of compaction. If required, additional water should be sprinkled from a sprinkler capable of applying water with a controllable rate of the flow, without any flooding. The water shall be added uniformly and thoroughly mixed in soil by blades. If the material at site is too wet, it shall be dried by aeration and exposure to the sun till the moisture content is acceptable.

xi) The number of passes to achieve the desired compaction will depend on the nature of soil and type of compaction plant. Compaction trials are to be conducted to demonstrate the efficacy of the equipment to be used.

xii) Each layer should be rolled to the camber/cross fall of the road and this should be maintained so as to prevent ponding.

3. Sub-Bases and Bases (Non-Bituminous)

A. Granular Sub-base

1) The physical requirements of material for granular subbase should be as per indicated in Table 2.3. The construction operations of granular subbase shall be carried out as per clause 401 of MORTH Specifications for Road and Bridge Works.

Table 2.3: Physical requirements for Materials for Granular Sub-base

Material Property	**IS Code**	**Value**
Aggregate Impact Value (AIV)	IS:2386 (Part 4) or IS:5640	40% maximum
Liquid Limit	IS:2720 (Part 5)	Maximum 25
Plasticity Index	IS:2720 (Part 5)	Maximum 6
CBR at 98% dry density (at IS:2720-Part 8)	IS:2720 (Part 5)	Minimum 30 unless otherwise specified in the Contract

B. Stabilized Soil Sub-base

1) Mechanical Stabilization consists of blending the missing fraction (clay with sand and sand with clayey soils) for improving gradation and bringing the plasticity within permissible limits. Gradation, plasticity and density are important controls. Lime-soil stabilization is a process of stabilization of clayey soils by the chemical action of lime on the clay minerals and can be used as lower subbase or improved subgrade. The soil used for stabilization shall be local clayey soil having plasticity index greater than 8. The lime used for lime soil stabilization shall be commercial dry lime having a purity of not less than 70 per cent by weight of quick lime. It should be properly stored to avoid prolonged exposure to the atmosphere. The soil for lime soil stabilization shall be pulverized so that it passes 100 per cent through 26.5 mm IS Sieve and passes 80 per cent by weight through I.S. Sieve 5.6 mm. The material used for cement or cement fly ash treatment shall be soil including sand and gravel, laterite, kankar, brick aggregate, crushed rock or slag or any combination of these. It shall meet the specified grading and shall have uniformity co-efficient not less than 5. If the material passing 425-micron sieve is plastic, it shall have liquid limit not greater than 45 percent and plasticity index of not greater than 20 percent. The cement shall either be OPC, PPC, or Portland Slag cement. The fly ash shall meet the specified requirement. The mix design for cement stabilization should be done based on 7-day unconfined compressive strength (UCS) and/or durability test under 12 cycles of wet dry conditions. The laboratory strength values should be at least 1.5 times the minimum field UCS taken for the pavement design. The mix design shall be done to achieve a strength of 1.75 MPa on cylindrical specimen.

C. Crushed cement concrete sub-base

1) This work consists of breaking and crushing the damaged cement concrete slabs and recompacting the same as sub-base in one or more layers. The thickness of each layer shall not exceed 75 mm compacted thickness. Coarse aggregate shall be broken cement concrete slabs crushed to a size not exceeding 75 mm and conforming in the specified grading. The crushed material shall be spread on the prepared subgrade with the help of a motor grader with three wheeled power rollers of 80 to 100 kN capacity or tandem or vibrating rollers of 80 – 100 kN static weight. The work shall be carried out as per clause 405 of MORTH Specifications for Road and Bridge Works.

D. Wet Mix Macadam (WMM)

1) The work shall consist of laying and compacting clean, crushed, graded aggregate and granular material premixed with water, to a dense mass on a prepared subgrade/ sub

base/base or existing pavement. The thickness of a single compacted WMM layer shall not be less than 75 mm. The compacted depth of a single layer of the subbase course may be upto 200 mm when vibrating or other approved types of compacting equipment are used. The aggregates shall conform to the physical requirements same as the WBM.

2) The construction operations shall be carried out as per clause 406 of MORTH Specifications for Road and Bridge Works. The mix should be prepared in approved mixing plant of suitable capacity having provision for controlled addition of water and forced/ positive mixing arrangement, like, pug mill or pan type mixer of concrete batching plant. The mixed material should be uniformly wet, and no segregation should be permitted. The mix should be spread uniformly and evenly in required quantities on the prepared subgrade/sub-base/base by a self- propelled paver finisher. In no case should the mix be dumped in heaps on the area. In exceptional cases, if permitted, motor grader may be used.

3) After the mix has been laid to the required thickness, the rolling shall be uniformly compacted by a suitable roller. 80-100 KN smooth wheeled roller may be used for a compacted thickness of not exceeding 100 mm. For a compacted single layer upto 200 mm the compaction shall be done with a vibratory roller of minimum static weight of 80-100 KN. The roller speed should not exceed 5 km/hour. Rolling should continue till density achieved is at least 98 per cent maximum dry density for the material as per IS:2720 (Part 8). When irregularity develop during rolling which exceeds 12 mm with a 3 m straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve uniform surface. It is not advisable to lay the wet mix macadam during rains and the tempo of work suffers during rains. After final compaction of the WMM course, the road shall be allowed to dry for 24 hours.

E. Crusher-run macadam base

1) Crusher-run macadam base is constructed of materials obtained from crushed rock only, satisfying physical requirements indicated in Table 2.4. If crushed gravel/shingle is used, minimum 90 per cent pieces retained on 4.75 mm size sieve should have at least two fractured faces. The works are to be carried out as per clause 407 of MORTH Specifications for Road and Bridge Works.

Table 2.4: Physical requirements of coarse aggregates for Crusher-run Macadam base

Sr. No.	Test	Test Method	Requirements
1	Los Angeles Abrasion Value	IS:2386 (Part 4)	40 %(Max)
2	Aggregate Impact Value	IS:2386 (Part 4) or IS:5640	30 %(Max)
3	Combined Flakiness and Elongation Indices	IS:2386 (Part 1)	35 %(Max)
4	Water absorption	IS:2386 (Part 3)	2% (Max)
5	Liquid Limit of material passing 425 microns	IS:2720 (Part – 5)	25 (Max)
6	Plasticity Index of material passing 425 microns.	IS:2720 (Part – 5)	6 (Max)

2) After the base course material has been deposited it shall be thoroughly blade mixed to full depth alternately from edges to center and back using water to moisten the materials sufficiently to prevent their segregation. Compaction may be done using 80 to 100 KN weight smooth wheel roller for single compacted thickness up to 100 mm. If vibratory

roller of minimum 80 to 100 KN is used single layer up to 200 mm can be compacted. The speed of roller should not exceed 5 km/hour. Each layer shall be compacted to not less than 98 per cent of maximum density as per IS:2720.

4. Bitumen Bound Bases and Surfacing

A. General Requirements

1) General requirements on materials, mixing, transporting, laying, compaction, joints and construction of bituminous pavement layers, protection of the environment etc. are laid down in Clause 501 of MORTH Specifications for Road and Bridge Works.

B. Prime Coat

1) Prime coat consists of application a single coat of low viscosity liquid bituminous material to a porous granular surface preparatory to the superimposition of bituminous treatment or mix. The primer shall be cationic bitumen emulsion SS1 grade or medium curing cut back bitumen. This work is to be carried out as per clause 502 of MORTH Specifications for Road and Bridge Work. Bituminous primer should not be applied during a dust storm, when the weather is foggy or rainy or windy or when the temperature in the shade is less than 10°C. After the application of cut-back, the surface should be allowed to cure for at least 24 hours.

C. Tack-Coat

1) The binder for tack coat should be either cationic bituminous emulsion (RS 1) or paving bitumen of VG-10 grades conforming to IS:73. Cut back bitumen RC 70 to be used restrictively for site at sub-zero temperature or for emergency application. The quantity of binder should be as per Table-2.5.

Table 2.5 - Rate of application of Tack Coat

Type of Surface	**Rate of spray of binder in kg/sq.m**
Bituminous surface	0.2-0.3
Granular surface treated with primer	0.25 – 0.30
Cement Concrete pavement	0.30 - 0.35

2) The binder should be applied uniformly with approved equipment capable of spraying bitumen at specified rate and temperature to provide a uniform unbroken spread of bitumen. The succeeding construction should be made only after curing the tack coat. The works are to be carried out as per clause 503 of MORTH Specifications for Road and Bridge Works.

D. Dense Bituminous Macadam (DBM)

1) The work consists of the construction of a single layer of compacted crushed aggregates premixed with bituminous binder for use in base/binder and profile corrective course. The thickness of single layer shall be 50 mm to 100 mm. Job mix formula for DBM shall comply with Clause 505.3.3 of the MORTH Specifications. The bitumen shall be viscosity grade paving bitumen as per IS:73, modified bitumen conforming to IRC-SP:53 and IS:15462. Plant trials and laying trials are to be carried out as per clause 505 of MORTH Specifications for Road and Bridge Works. The construction operation for DBM including laying of and stress absorbing layer, should be in accordance with Clause 505.4 of the MORTH Specifications for Road and Bridge Works.

E. Bituminous concrete (BC)

1) The work consists of construction of bituminous concrete for use in wearing and profile corrective courses. This work consists of construction in a single layer on previously prepared bituminous bound surface. A single layer shall be 30 mm/40 mm/50 mm thick.

Mix design and construction operations for bituminous concrete should conform to Clauses 507.3 and 507.4 of the MORTH Specifications for Road and Bridge Works respectively.

Table 2.6- Physical requirements for coarse aggregates for bituminous concrete

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I
Particle shape	Combined Flakiness and Elongation Indices	Max 35%	IS:2386 Part I
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 30% Max 24%	IS:2386 Part IV
Durability	Soundness either Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%	IS:2386 Part V
Polishing	Polished Stone Value	Min 55	BS:812-114
Water Absorption	Water absorption	Max 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%*	IS:6241
Water Sensitivity	Retained Tensile Strength	Min 80%*	AASHTO 283

1) The nominal maximum particle size is the largest specified sieve size up on which any of the aggregate is retained. ** Corresponds to specific gravity of aggregate being 2.7. In case aggregate have specific gravity more than 2.7, the minimum bitumen content can be reduced proportionately. Further the region where highest daily mean air temperature is 30°C or lower and lowest daily air temperature is – 10°C or lower, the bitumen content may be increased by 0.5 percent.

F. Mastic asphalt

1) This work shall consist of constructing a single layer of mastic asphalt wearing course for road pavements and bridge decks. This is not for the thin layer on bridge decks below a bituminous concrete layer. Mastic asphalt is composed of suitably graded mineral filler and coarse aggregates, fine aggregates and hard grade bitumen as to form a coherent, void less impermeable mass, solid or semi solid under normal temperature conditions but sufficiently fluid when brought to a suitable temperature to be spread by means of a float in manual construction and by paver in mechanized construction. The binder for the mastic asphalt shall be a industrial grade 85/25 bitumen.

G. Reclamation, Recycling and Reprocessing of the Existing Pavement:

The existing flexible Pavement shall be restored by a sustainable process and the existing pavement materials—primarily aggregates and bituminous binders shall be reclaimed and reused after undergoing reprocessing as per IRC 120 : 2015. This can be applied for resurfacing, repaving, or complete reconstruction, depending on the current condition of the pavement, the properties of the reclaimed materials, and the required treatment.

The pavement designs shall accommodate the specific characteristics of reclaimed materials utilizing appropriate methods, equipment, and quality control measures to efficiently reclaim and reprocess materials. Design and technology shall be properly managed so that recycled pavements can deliver high performance in terms of strength, durability, and serviceability.

2.4 Paver Block

A. Scope - The paver blocks are proposed to be used for Pedestrian Ways, Paved shoulders and Footpaths. The interlocking paver block of 80 mm thickness to be used for pedestrian ways and footpaths.

B. Material - Bedding Sand Course: The bedding sand shall consist of a clean well graded sand passing through 4.75mm sieve and suitable for concrete. The bedding should be from either a single source or blended to achieve the following grading.

Table 2.7 Bedding and Jointing Sand Requirement

In Sieve size	% passing for bedding	% passing for jointing
9.52	100	-
4.75	95-100	-
2.36	80-100	100
1.18	60-100	90-100
600 micron	25-60	60-90
300 micron	10-30	30-60
150micron	5-15	15-30
75 micron	0-10	10-20

1) The Contractor shall be responsible for ensuring that single-sized, gap-graded sands or sand containing an excessive fines or plastic fines are not used. The sand particles should preferably be sharp not rounded as sharp sand possess higher strength and resist the migration of sand from under the block to less frequent areas even though sharp sands are relatively more difficult to compact than rounded sands, the use of sharp sands is preferred for the more heavily trafficked driveways. The sand use for bedding shall be free of any deleterious soluble salts or other contaminants likely to cause efflorescence.

2) The sand shall be of uniform moisture content and within 4% - 8% when spread and shall be protected against rain when stockpiled prior to spreading. Saturated sand shall not be used. The bedding sand shall be spread loose in a uniform layer as per drawing. The compacted uniform thickness shall be of 45mm and within +/- 5mm thickness variation shall not be used to correct irregularities in the base course surface.

3) The spread sand shall be carefully maintained in a loose dry condition and protected against pre- compaction both prior to and following screening. Any pre- compacted sand or screened sand left overnight shall be loosened before further laying of paving blocks take place.

4) Sand shall be slightly screened in a loose condition to the predetermined depth only slightly ahead of the laying of paving unit.

C. Ready Mix Concrete

1) The concrete mix design should be followed for each batch of materials separately and automatic batching plant is to be used to achieve uniformity in strength and quality.

2) The concrete pavers should have perpendiculars after release from the mould and the same should be retained until the laying. The surface should be of anti- skid and anti-glare type. The pave should have uniform chamfers to facilitate easy drainage of surface run off. The pavers should have uniform interlocking space of 2mm to 3mm to ensure compacted sand filling after vibration on the paver surface.

D. Manufacturing & strength

1) The pavers shall be manufactured in single layer only. Paver block machine should be used for manufacturing the blocks. The manufacturing of the paver block should meet the requirements as per IS: 15658-2006.

2) The average compressive strength of the 80mm thick paver blocks tested shall be 40 N/Sq. mm. as per the Table 3 Compressive Strength Requirements of Concrete Paver Blocks of IS 15658- 2006.

E. Laying & Interlocking

1) Once the laying pattern has been established, it shall continue without interruption over the entire pavement surface. Cutting of blocks, the use of infill concrete or discontinuities in laying pattern is not permitted in other than approved locations.

2) Paver blocks shall be laced on the un-compacted screened sand bed to the nominated laying pattern, care being taken to maintain the specified bond throughout the job. The first row shall be located next to an edge restraint. Specially manufactured edge paving blocks are permitted, or edge blocks may be cut using a power saw, a mechanical or hydraulic guillotine, bolster or other approved cutting machine.

3) Paver blocks shall be placed to achieve gaps nominally 2 to 3 mm wide between adjacent paving joints. No joint shall be less than 1.5mm not more than 4mm. Frequent use of string lines shall be used to check alignment. In this regard, the "laying face" shall be checked at least every two metres as the face proceeds. Should the face become out of alignment, it must be corrected prior to initial compaction and before further laying job is proceeded with.

4) In each row, all full blocks shall be laid first. Closure blocks shall be cut and fitted subsequently. Such closer blocks shall consist of not less than 25% of a full block.

5) To infill spaced between 25mm and 50mm wide concrete having screened sand, coarse aggregate mix and strength of 40 N/Sq mm. shall be used. Within such mix the nominal aggregate size shall not exceed one-third the smallest dimension of the infill space. For smaller spaces dry packed mortars shall be used.

6) Except where it is necessary to correct any minor variations occurring in the laying bond, the paver blocks shall not be hammered into position.

7) Where adjustment of paver blocks necessary care shall be taken to avoid premature compaction of the sand bedding.

8) Initial Compaction: After laying the paver blocks, they shall be compacted to achieve consolidation of the sand bedding and brought to design levels and profiles by not less than Two passes of a suitable plate compactor or baby roller of suitable capacity.

9) The compactor shall be a high-frequency, low amplitude mechanical flat plate vibrator having plate area sufficient to cover a minimum of twelve paving blocks. Prior to compaction all debris shall be removed from the surface compaction shall proceed as closely as possible following laying and prior to any traffic. Compaction shall not, however, be attempted within one meter of the laying face. Compaction shall continue until lipping has been eliminated between adjoining blocks. Joints shall then be filled and recompacted.

10) All work further than one meter from the laying face shall be left fully compacted at the completion of each day's laying.

11) Any blocks that are structurally damaged prior to or during compaction shall be immediately removed and replaced.

12) Sufficient plate compactors shall be maintained at the paving site for both bedding compaction and joint filling.

13) Joint Filling and Final Compaction: As soon as possible after compaction and in any case prior to the termination of work on that day and prior to the acceptance of vehicular traffic, sand for joint filling shall be spread over the pavement.

14) Joint sand shall pass a 2.36mm (No.8) sieve and shall be free of soluble salts or contaminants likely to cause efflorescence. The same shall comply with the following grading limits.

F. Sand for bedding

1) The Contractor shall supply a sample of the jointing sand to be used in the Contract prior to delivering any such materials to site for incorporation into the works. Certificates of test results issued by a recognized testing laboratory confirming that the samples conform to the requirements of these specifications shall accompany the sample.

2) The jointing sand shall be boomed top fill the joints. Excess sand shall then be removed from the pavement surface and the jointing sand shall be compacted with not less than one (1) Pass by the plate vibrator and joints refilled with sand to full depth. This procedure shall be repeated until all joints are completely filled with sand. No traffic shall be permitted to use the pavement until all joints have been completely filled with sand and compacted.

3) Both the sand and paver blocks shall be dry when sand is spread and broomed into the joints to prevent premature setting of the sand.

4) The difference in level (lipping) between adjacent blocks shall not exceed 3mm with not more than 1 % in any 3m x 3m area exceeding 2mm. pavement which is deformed beyond above limits after final compaction shall be taken out and reconstructed to the satisfaction of the Authority Engineer.

G. Edge Restraint:

1) Edge restrains need to be sufficiently robust to withstand override by the anticipated traffic, to withstand thermal expansion and to prevent loss of the laying course material from beneath the surface course. The edge restraint should present a vertical face down to the level of the underside of the laying course. The surface course should not be vibrated until the edge restraint, together with any bedding or concrete launching, has gained sufficient strength. It is essential that edge restraints are adequately secured.

Section 3

Cut & Cover Tunnels and Ramps

3.1 INTRODUCTION

This Section specifies the design standards, materials, construction methods, workmanship, instrumentation and monitoring requirements for the design and construction of Cut & Cover Tunnels, Open Ramps, Underground Ramps, Transition Structures, and associated underground and above-ground civil structures, including but not limited to retaining walls, diaphragm walls, secant pile walls, deck slabs, base slabs, portals, ventilation structures, sump chambers, utility corridors and service buildings.

All Works shall be designed and executed to ensure structural safety, serviceability, durability, traffic safety, constructability, and minimum impact on adjacent Existing Building Structures (EBS).

3.2 DESIGN CONSIDERATIONS – CUT & COVER TUNNEL & RAMPS

3.2.1 Method Statement

1. The Contractor shall submit a detailed Design Report including design basis, assumptions, calculations, drawings, construction staging, temporary works, traffic management and protection of EBS prior to commencement of Works.
2. A comprehensive method statement shall be submitted covering:

- Excavation sequence
- Retaining systems (D-wall / secant pile / sheet pile / soldier pile)
- Strutting / anchoring systems
- Dewatering and groundwater control
- Base slab casting, walls, roof slab, ramp slabs
- Backfilling and reinstatement

3. The Contractor shall ensure **ground movements, settlements and groundwater drawdown** are within permissible limits affecting adjacent roads, utilities, buildings and structures.

3.2.2 Types and General Methods of Analysis

1. Tunnel and ramp geometry shall conform to **Schedule-B**. Any improvement proposed by the Contractor shall not involve additional cost or time and shall be subject to Authority approval.
2. Excavation stability, temporary works, and permanent structures shall be analyzed using:

- Limit equilibrium methods
- Finite Element / Finite Difference analysis
- Soil-structure interaction models

3. Excavation shall be carried out in a controlled and staged manner. Over-excavation shall be minimized.
4. Where surface settlement limits are specified, the Contractor shall demonstrate compliance through analytical modelling and monitoring plans.

3.2.3 Design Method

1. Structural design shall consider:

- Construction stages
- Temporary load cases

- Long-term operational conditions

2. Design shall account for **soil–structure interaction**, groundwater pressure, creep, shrinkage, seismic effects and differential settlements.
3. Temporary works shall be designed independently and shall not be relied upon for long-term structural capacity unless explicitly approved.
4. The Contractor shall carry out **additional ground investigations**, if required, at his own cost.

3.2.4 Loads

The design shall consider, but not be limited to:

- Dead load including self-weight and overburden
- Traffic loads (IRC Class AA / 70R as applicable)
- Earth and groundwater pressure
- Surcharge loads from adjacent buildings
- Seismic loads
- Construction loads
- Temperature, shrinkage and creep effects

3.2.5 Loading Conditions

1. Cut & Cover tunnel structures shall be designed for:

- Full excavation stage
- Partial construction stage
- Completed structure with backfill
- Operational stage

2. Hydrostatic pressure shall be considered for:

- Normal groundwater level
- Flood condition (1 m above 20-year flood level or 1.5 m above HFL)

3.2.6 Flotation and Uplift

1. All underground structures including tunnel boxes, ramp boxes and sumps shall be checked for flotation assuming groundwater at ground level.
2. Minimum Factor of Safety against uplift = 1.10.
3. Anti-flotation measures may include:

- Structural dead weight
- Ground anchors
- Shear keys

3.2.7 Crack Width Control

1. Structural concrete shall comply with **IS:456**.
2. Maximum crack width limits:

- Ground-facing surfaces: **0.2 mm**
- Non-ground-facing surfaces: **0.3 mm**

3.2.8 Settlement and Heave

1. All structures shall be checked against:
- Base heave
- Lateral wall movement
- Surface settlement
2. Where critical, refined numerical analysis shall be carried out.

3.3 CUT & COVER TUNNEL & RAMP STRUCTURES

3.3.1 Structural Configuration

The permanent works shall include:

- Base slab
- Side walls
- Roof slab
- Intermediate slabs (if any)
- Open ramps and underground ramps
- Portal structures
- Retaining walls and wing walls

3.3.2 Waterproofing

1. Waterproofing systems shall include:
- External membrane
- Construction joint water bars
- Injection hoses
2. Permissible leakage:
- **≤ 0.1 L/m²/day**
3. Materials shall be fire-resistant and durable.

3.3.3 Sumps and Drainage

1. Sumps shall be provided at all low points.
2. Sump design shall consider:
- Inflow rate
- Pump capacity
- Redundancy
- Emergency storage
3. Permanent power supply and access provisions shall be provided.

3.3.4 Underpinning of Existing Structures

1. Where excavation affects existing foundations, the Contractor shall design and execute **underpinning / protection works**.
2. Cost shall be deemed included in the Contract Price.

3.4 GROUND TREATMENT & TEMPORARY SUPPORT

1. Ground improvement may include:

- Jet grouting
- Soil nailing
- Ground anchors
- Micropiles

2. Detailed designs and method statements shall be submitted for approval.

3.5 INSTRUMENTATION & MONITORING

1. Monitoring shall cover:

- Ground settlement
- Wall deflection
- Building movement
- Groundwater levels
- Structural behavior

2. Monitoring shall start **before excavation** and continue until movements stabilize for **minimum three months**.
3. Trigger levels:

- Alert: 0.5 × serviceability limit
- Action: 0.8 × serviceability limit
- Alarm: 1.0 × serviceability limit

4. Vibration limits shall comply with:

- DIN 4150-3
- IRC SP-91
- Indian Railways / Metro standards

3.6 ABOVE-GROUND STRUCTURES

1. Above-ground structures such as:

- Ventilation buildings
- Entry/exit buildings
- Control rooms shall be designed for:
- Seismic loads
- Wind loads
- Architectural integration

2. Durability requirements:

- Main structural elements: **100 years**
- Non-structural components: **50 years**

3.7 Sumps in Running Tunnel

1) Sumps shall be located at every low point within each running tunnel.
2) Wherever practicable the vertical alignment shall be chosen such that the locations of sumps avoid critical sections where their construction could have an adverse effect on adjacent structures.
3) The size of each sump shall take account of the anticipated rate of flow into the sump, the priority rating, the number and types of pumps to be installed and the reserve capacity required above alarm level.
4) The reserve capacity of a groundwater seepage sump shall be calculated on the basis of the area of tunnel lining applicable to the sump in accordance with the following formula.

VR = A * v * t * F.O.S. *10-3

Where,

VR = Volume of reserve, m3

A = Tunnel lining area, m2

v = Maximum leakage rate, l/m2/day

t = Maximum response time, (day)

F.O. S = Factor of Safety

5) For running tunnel low point sumps, the response time "t" shall be 24 hours and the factor of safety shall be 1.5.
6) The sump design shall include outlets for the longitudinal drainpipe and discharge mains, pumps of suitable capacity and power connection. Sumps shall be fitted with steel covers and provided with step irons or access ladder as approved. Permanent discharge mains shall be installed as well as embedment of conduits for permanent electric power cables to the pumps.
7) The linings of the sumps shall be designed for the appropriate ground and groundwater loads.
8) The design and construction of the junctions with the running tunnel linings shall be in accordance with the general requirements of these Outline Design Specifications.

3.8 Ground Treatment and Temporary Support

1) For all bored-tunnel sections, a plan shall be prepared, based on all of the available data, of the anticipated need for and methods of providing the following.

(i) Ground treatment at break-in / break-out locations

(ii) Ground treatment in advance of the tunnel excavation.

(iii) Temporary support during tunnel excavation.

2) This information and the assumptions on which it is based shall be shown on the design drawings. The effect of tunnelling activities on structures located above the line of the tunnel shall be determined and any remedial action necessary to minimize the settlement of these structures shall be implemented prior to tunnel excavation.
3) Detailed materials and workmanship specifications shall be provided for the use, if any, of shotcrete, or rock bolts, or both as part of any final/permanent liner or support system for tunnel.

3.1.1 Ground Movements

1) The design of all Temporary and Permanent Works shall limit ground movement and

distortions around the site and avoid damage to adjacent EBS.

2) The Contractor shall carry out a risk assessment for all EBS within the influence zone of the Works. The analysis for the Temporary Works shall be properly related to the conclusions of this risk assessment.

3.1.2 Construction Dewatering

1) Temporary dewatering of construction excavations will be required to provide an undisturbed, stable and dry subgrade to permit construction and backfilling of the Permanent Works under dry conditions.

2) In general, the groundwater within the excavations shall be maintained at a level that permits achievement of the above and avoids heave, piping or base failure of the excavation.

3) Temporary dewatering methods (including recharging methods, if required) and system operations, along with other required temporary works, shall not lower the groundwater outside the walls supporting the excavations, nor result in undue settlement, distortion or loss of ground at adjacent EBS. In this respect, all the provisions/stipulations of the Contract pertaining to the permissible limits of groundwater table drawdown and protection of EBS (limits of EBS damage) shall be fully complied with.

4) The Contractor shall prepare and submit his design of his construction dewatering system (including recharging system, if required) to the Authority/ Authority Engineer for his Notice of No Objection. The construction dewatering design shall include determination of subsurface conditions and geotechnical design parameters, analysis to establish feasible methods, and system definition in sufficient detail to demonstrate that the general objectives can be achieved without adverse effect on adjacent EBS. The selected system shall generally provide for continuous (24-hour per-day) operation, adequate reserve equipment, and standby power.

3.1.3 Ground Improvement

1) Ground-improvement may be required along certain alignment segments of the Contract to control ground and EBS movement and distortion that may be induced by excavation and tunnelling and at tunnel break-in/break-out locations, in advance of bored tunnel excavation.

2) The Contractor shall prepare and submit his designs and method statements supported by analysis for all ground improvement to the Authority Engineer for his Notice of No Objection. These designs shall define performance objectives for the ground improvement

3) The information and assumptions on which the ground improvement is based shall be shown on the design drawings.

3.2 Instrumentation

1) The Contractor shall instrument, monitor and report on ground and EBS movement and distortion, groundwater level, stress and displacement in the excavation and lateral support system, structural movement during construction to check his predictions

2) Monitoring shall be carried out on a case-by-case day-to-day or more frequent basis depending upon the importance of EBS and/or the risk of damage to that EBS. Special attention shall be paid to the historical buildings and wells located along the alignment.

3) Monitoring shall begin prior to commencement of the Works to enable instrument base-line values to be determined accurately and shall continue until all movements and distortions to the ground and EBS, and changes to the groundwater table that might be attributed to the Works, as shown by the monitoring, have effectively ceased for a period of three months.

4) The Contractor shall submit a complete comprehensive instrumentation, monitoring and reporting scheme with his Design and prior to any construction which is designed to achieve the following.

   (i) To establish typical background movement, distortion, groundwater fluctuation, and noise and vibration limits for the ground, groundwater and EBS prior to

commencement of the Works.

(ii) Protection to all parties during and after the construction by providing early warning of any excessive and undue movement and distortion of the adjacent ground and EBS.

(iii) To provide movement and deformation information for design verification of the Temporary and Permanent Works.

(iv) To ensure that the maximum allowable tolerances associated with various structures/elements within the zone of influence of the Works are not exceeded.

(v) To confirm that groundwater drawdown outside of the excavations does not exceed the expected fluctuation limits

5) Vibration recording devices shall be provided to monitor for vibrations which may cause damage to the proposed constructions and EBS. These devices shall be installed at intervals and locations to provide comprehensive coverage of the Works. Unless otherwise directed by the Fire/Life Safety Committee, these devices shall record ground accelerations generated by the Works to ensure that these accelerations do not exceed the values set by the relevant Authorities or those determined by the Contractor for the stability and safety of the Temporary and Permanent Works and adjacent EBS.

6) **Limiting Construction-Induced Vibrations at adjacent EBS**

In the design, the effects of construction-related vibrations shall be considered. Unless otherwise accepted by the applicable government agencies and the Authority Engineer peak particle velocities at adjacent EBS shall not exceed the values in the Table below (as per AASHTHO -1990 & DIN 4150 -3,1999):

7) Peal **Particle Velocities in mm/sec (max. Allowable) at adjacent EBS**

Existing Adjacent Structures	Peak Particle Velocities in mm/sec (Max. allowable)
Most structures in “good” condition	25
Most structures in “fair” condition	12
Most structures in “poor” condition	5
Water-supply structures	5
Heritage structures/bridge structures	5

8) Above limits are maximum permissible, however this may have to be restricted further if required to avoid damage to the adjacent EBS or causing discomfort to the occupants. Along the proposed alignment, other limitations may be imposed at adjacent EBS, such as hospitals, school buildings, telephone-exchange structures, special water- supply structures and Heritage structures etc. In addition, working hours for such equipment’s causing vibrations may have to be restricted, keeping the convenience and comfort of the occupants in mind

9) **EBS Protection**

a) The Contractor shall minimize the induced loads, and total and differential deflections (angular distortion) of the ground surface and EBS above or below the ground surface that may result from the Works. The impacts of construction shall be so limited as to not affect the operation of the EBS, road and pavement.

b) “Green-field” condition shall be considered in determining the total and differential deflections of the ground and EBS.

10) Instrumentation, Monitoring and Reporting.

a) The Contractor shall instrument, monitor, and report on ground and EBS movements and distortions, groundwater levels, stresses and displacements in the excavation and lateral support systems, structural movements during construction to validate and check his predictions.

b) Instrumentation and monitoring arrangements for ground and existing building structures (EBS) movement and distortion and changes to ground water table(s) and the trigger (Alert, Action and Alarm) levels for each and every identified EBS to be performed. Designer has to specify the required instrumentation and monitoring arrangement to maintain the saftey of the EBS.

c) Monitoring shall be carried out on a case-by-case day-to-day or more frequent basis depending upon the importance of EBS and/or the risk of damage to that EBS.

d) Special attention shall be paid to the heritage/historical buildings, sensitive structures and wells located along the alignment.

e) Monitoring shall begin prior to commencement of the Works to enable instrument base-line values to be determined accurately and shall continue until all movements and distortions to the ground and EBS, and changes to the groundwater table that might be attributed to the Works, as shown by the monitoring, have effectively ceased for a period of three months.

f) The Contractor shall submit a complete comprehensive instrumentation, monitoring and reporting scheme with his Design and prior to any construction which is designed to achieve the following.

(i) To establish typical background movement, distortion, groundwater fluctuation, and noise and vibration limits for the ground, groundwater and EBS prior to commencement of the Works.

(ii) Protection to all parties during and after the construction by providing early warning of any excessive and undue movement and distortion of the adjacent ground and EBS.

(iii) To provide movement and deformation information for design verification of the Temporary and Permanent Works.

(iv) To ensure that the maximum allowable tolerances associated with various structures/elements within the zone of influence of the Works are not exceeded.

(v) To confirm that groundwater drawdown outside of the excavations does not exceed the expected fluctuation limits

g) Vibration recording devices shall be provided to monitor for vibrations which may cause damage to the proposed constructions and EBS. These devices shall be installed at intervals and locations to provide comprehensive coverage of the Works. Unless otherwise directed by the Relevant Fire/Life Safety/any other Agencies/Authorities, these devices shall record ground accelerations generated by the Works to ensure that these accelerations do not exceed the values set by the Relevant Authorities or those determined by the Contractor for the stability and safety of the Temporary and Permanent Works and adjacent EBS.

The standard vibration limits for different types of structures located above or near tunnel construction sites, particularly during tunnel excavation using cut-and-cover method. These values are derived from national and international guidelines including Indian Railways, ISO 4866, and German DIN 4150-3 standards, which are often referred to in Indian urban tunneling projects:

Vibration Limits for Structures Above Tunnel – Indian Context

Structure Type	Description	Peak Particle Velocity (PPV) Limit	Reference Standards
Heritage Structures / Ancient Monuments	Buildings of historical importance or fragile architecture	≤ 2 mm/s	DIN 4150-3 (Category 1), ASI Guidelines
Residential Buildings (Good Condition)	Brick masonry or RCC frame structures used for housing	≤ 5 mm/s	DIN 4150-3 (Category 2), IS 14894
Commercial / Public Buildings	RCC structures, multi-story buildings with high occupancy	≤ 8–10 mm/s	DIN 4150-3 (Category 3), Indian Railways
Industrial Buildings	Heavy RCC or steel-framed structures	≤ 10–15 mm/s	DIN 4150-3, BS 7385
Critical Infrastructure	Hospitals, data centers, laboratories, schools, etc.	≤ 5 mm/s	IRC-SP:91-2019, ISO 4866
Underground Utilities (Pipelines, Sewers)	Near tunnel alignment zone (usually <10m)	≤ 3 mm/s	Project-specific safety limits
Railway Tracks / Metro Corridors	Existing tracks or operational tunnels nearby	≤ 5 mm/s	Indian Railways Manuals, DMRC Specs

Notes:

- PPV values are measured in millimeters per second (mm/s) and represent the peak vibration speed in any of the three axes (x, y, z).
- These limits should be verified through baseline structural condition surveys and continuous vibration monitoring.
- The limits may be lowered in case of weak soil strata, shallow foundations, or differential settlement risk.
- In India, project-specific limits are often finalized based on geotechnical study, structural audit, and IE/PMC recommendation.
- Monitoring should be carried out using geophones or accelerometers placed at strategic points, linked to a data logger with alert thresholds.

Notes:

1. The table is based on the work of Burland et al (1977) and includes typical maximum tensile strains for the various damage categories (column 5) used in the stage 2 settlement analyses
2. Crack width is only one aspect of damage & should not be used on its own as its direct measure.

3.3 GENERAL

(1) The work shall be carried out in compliance with the Health and Safety requirements as detailed within the Authority's Requirements.

(2) All work shall be carried out in compliance with the Acts, Rules and Regulations of Government of India & Government of Karnataka State.

(3) The Material and Workmanship Specifications shall be adopted by the Contractor and

their Designer(s) considering the chosen methodology. The Contractor Material and Workmanship Specifications shall as a minimum comply with all applicable Indian Standards and Codes and relevant International Standards and Codes as applicable.

(4) The specifications contained in this section are the minimum expected to achieve the performance requirements of design and execution.

3.4 SURVEY

(1) Before commencement of any construction work, the Contractor shall prepare and submit appropriate survey method statements relating to his proposed methods of working.

(2) The Contractor shall establish a system for underground surveying, setting out and correcting deviations from theoretical alignment, using a laser-based system. Reference points and targets shall be used in conjunction with lasers to ensure the accuracy of the system and it should be easy to monitor by the Authority Engineer. Laser-based guidance systems should have an alternative system as back-up.

(3) If at any time during the excavation of the tunnel, it is evident that the alignment for the tunnel is outside the specified/permissible tolerances then, before proceeding further with the excavation, the Contractor shall submit his proposal for the necessary corrections to the alignment, and the Contractor shall forthwith make the corrections as accepted by the Authority Engineer.

3.5 FIELD CONTROL AND MONITORING EQUIPMENT

1) Setting out of Line, level and Profile

Prior to starting underground work, the Contractor shall submit to the Authority Engineer proposals on the setting out the Works and for correcting any deviations.

2) **Chainage**

Markers shall be provided in tunnels at 10 m intervals. The markers shall be painted in white durable paint.

3) Markers and Benchmarks.

The Contractor shall provide the Authority Engineer with the location and description of all survey stations, and all survey data.

3.5.1 Monitoring Equipment

(1) **For Monitoring inside the Tunnel:** The Contractor shall provide basic equipment for measurement of deformations and alignment inside the tunnels, at least by using levelling instruments, wire extensometer for convergence measurement, 3 D optical targets for 3D displacement monitoring. The instrumentation scheme shall be proposed by the Contractor and agreed by the Authority Engineer.

(2) **Ground Surface Monitoring:** The Contractor shall provide Instrumentation and monitoring scheme for measurement of ground settlement along the tunnel axis and up to the influence zone in transverse direction. Such ground improvements shall be monitored by providing ray of ground settlement markers at particular intervals and the frequency of the measurement of these settlement markers shall be defined with respect to the advancement of the tunnel. The detailed scheme shall be proposed by the Contractor and agreed by the Authority Engineer.

(3) **Monitoring of critical Utilities and Buildings in the influence zone of Tunnel axis:** The Contractor shall provide Instrumentation and monitoring scheme for the sensitive structures and utilities falling in the influence zone of the tunnel drive. The instruments can be Tilt meters, 3D Targets, Settlement Markers etc. The detailed Instrumentation and Monitoring scheme shall be proposed by the Contractor and agreed by the Authority Engineer. In critical locations online monitoring shall be proposed by the Contractor and shall be agreed by the Authority Engineer.

(4) During the execution of excavation work, the Contractor needs to procure supplementary types of equipment as may be required for standard tunnelling methods.

(5) Measurements of all types of equipment shall be performed by the Contractor as directed by the Authority Engineer. Results from each measurement shall be submitted to the Authority Engineer within 24 hours.

3.6 Structural Concrete

3.6.1 General

(1) The Contractor shall establish a modern concrete laboratory with trained Authority Engineer s, Quality Control (QC) Manager and technicians at the casting yard. The laboratory shall contain facilities for testing physical properties of cement, workability of concrete, cube strength, permeability, sieve analysis, RCPT, aggregate tests, tests required for mix design, chloride and sulphate tests of water and admixture, concrete temperature, oven, accelerated tests for cement/concrete strength, flexural strength of concrete etc. One room shall be air-conditioned to control temp and humidity for cement tests.

(2) All off-site material sampling and testing shall be done at laboratories accredited by NABL (National Accreditation Board of Testing and Calibration Laboratories) or internationally accredited laboratory to ISO 17025.

(3) The Contractor shall submit to the Authority Engineer full details and samples of all materials which he proposes to use for the manufacture of the precast tunnel lining at least 60 days before the commencement of manufacturing and obtain Notice to Proceed from the Authority Engineer. Any subsequent change in these materials, proposed by the Contractor shall not be permitted unless a Notice to Proceed has been obtained from the Authority Engineer.

(4) Polypropylene Fibers

PP Fibers shall conform to relevant International/National Standards or as instructed by Authority Engineer.

Micro Synthetic fibers may be required to be added to concrete to enhance structural durability and desired structural performance in case of fire. When such fibers are required, Contractor shall ensure that:

i. Micro synthetic fibers shall be CE certified (with Declaration of Performance certificate) in conformance to EN 14889-2.

ii. Fibers shall be dry and free from oil, grease and chlorides and shall be provided with arrangements to deliver anchorage properties. The fibers shall satisfy the following parameters:

a. Storage: Fibers shall be stored, handled and dosed in accordance with the manufacturer's recommendations. Generally, this will require them to be stored in dry, sealed containers until ready for use and shall be free from oil, grease, chlorides and deleterious materials which may reduce the efficiency of mixing or spraying processes, or which may reduce bond between the fibers and the concrete.

b. Fibers shall be dosed by automatic dosing system. Mixing procedure adopted by the Contractor should be such that there is no fiber balling.

Polypropylene fibers for reduction of spalling of final lining concrete in case of fire. Polypropylene Fibers (microfibers) shall be 100% polypropylene and conform to the requirement of European Standard EN14889-2 "Fibers for concrete – Part 2". Fibers shall have a round cross section with a diameter of 15 - 20µm and be slightly crimped. Fibers' length shall be minimum 6mm. The tensile strength of fibers shall be at least 400N/mm^2. The melting point shall be at 150 - 160 oC. Minimum 2 kg of PP microfibers to be added per cubic meter of lining concrete

3.6.2 Source of Materials:

1) All the sources of the materials shall require Authority Engineer Notice to Proceed in advance before bringing to the site. All materials for making concrete shall require Authority Engineer ’s Representative Notice to Proceed. A sample of material shall be deposited in the office of the Authority Engineer before placing orders for the materials with suppliers. The materials brought on to the works shall conform in every respect to their samples and specifications which have Notice to Proceed.

2) Fresh samples shall be deposited with Authority Engineer whenever type or source of any material changes. The Contractor shall check fresh consignment of materials as it is brought on to the works to ensure that they conform to the specifications.

3) The Authority Engineer shall have the option to have any of the materials tested to find whether they are in accordance with specifications at the Contractor 's expense. All bills, vouchers and test certificates which in the opinion of the Authority Engineer are necessary to convince him as to the source and quality of materials or their suitability shall be produced for his inspection when required.

4) Any materials which have not been found to conform to the specifications and/or without Notice to Proceed by the Authority Engineer shall be rejected forthwith and shall be removed from the site by the Contractor at his own cost within the time stipulated by the Authority Engineer. The Authority Engineer shall have the powers to cause the Contractor s to purchase and use materials from any particular source, as may in his opinion, are necessary for the quality execution of work.

5) Contractor shall also ensure that all constituents of exposed concrete shall be taken from same sources to achieve a uniform colour and texture. Cement/blended cement/Cementitious material: They all will mean the same thing.

   The cement or cementitious material used shall be of the following types:

   i. 43 grade Ordinary Portland Cement conforming to IS: 8112.
   ii. 53 grade Ordinary Portland Cement conforming to IS: 12269.
   iii. PPC as per IS: 1489 (Part-I)
   iv. PSC as per IS: 455
   v. Fly ash as per IS: 3812 (Part I & II)
   vi. Whenever possible all cements of each type shall be obtained from one constant source throughout the Contract, cement of different types shall not be mixed together. Different brands of cement, or the same brand of cement from different sources, shall not be used without Authority Engineer ’s Notice to Proceed.

   Packaged cement shall be delivered to the site in original sealed bags which shall be labelled with the weight, name of manufacturer, brand and type. Cement received in torn bags shall not be used. Cement bags will not be handled with hooks which allow ingress of moisture.

   Material which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the site. Contractor may obtain cement in bulk and store it in suitable silos of adequate capacity. Each type of cement shall be stored in a separate silo and it shall be ensured, that cements of different quality are not mixed up.

   All cement shall be fresh when delivered and at ambient atmospheric temperature. In fair faced elements, the cement used in the concrete for any complete element shall be from a single consignment. All cement for exposed concrete shall be from the same source and uniform in colour. With each and every delivery of cement the Contractor shall provide manufacturer’s certificate that the cement conforms to the relevant Indian standard. The Contractor shall provide complete facilities at site for carrying out the following tests:

a. Setting time by Vicat's apparatus as per IS: 4031 and IS: 5513.

b. Compressive strength on cement as per IS: 4031, IS: 650, IS: 10080.

c. Total chloride content in cement shall in no case exceed 0.05 percent by mass of cement. Also, total sulphur content calculated as sulphuric anhydride (SO3), shall in no case exceed 2.5 percent and 3.0 percent when tri-calcium aluminate per cent by mass is greater than 5 or less than 10 respectively.

d. The cement will be blended with processed fly-ash conforming to IS specifications Cement and cement extenders shall be free flowing and free of lumps and shall be supplied in the manufacturer's sealed unbroken bags or in bulk. The temperature of the cement when added to the mixer shall not exceed 40° C unless otherwise agreed by the Authority Engineer.

All cement and cement extenders used in the Works shall be tested by the manufacturer or the Contractor in a laboratory which has Authority Engineer Notice to Proceed. Copies of all test results so obtained shall be delivered to the Authority Engineer before the cement and cement extenders are incorporated in concrete. All cement extenders used shall comply with the appropriate Indian standards for Fly Ash (FA) or Condensed Silica Fume (CSF) respectively as detailed above.

The Contractor shall keep full records of all data relevant to the manufacture, delivery, testing and use of all cement and cement extenders used in the Works and shall provide the Authority Engineer with two copies thereof.

If the Contractor proposes to use a Type 1 Portland Cement, he shall only do so by blending it with a Noticed cement extender that has been issued Notice to Proceed by Authority Engineer.

Blending of Type 1 cement with an extender may be done, in the batch plant, or at a commercial blending plant.

Each set of tests carried out by the manufacturer or Contractor shall relate to not more than one day's output of each cement plant and shall be made on samples taken from cement which is subsequently delivered to the Site. Alternatively, the frequency of testing shall be one set of tests for every 200 tonnes of cement delivered to Site from each cement plant.

Cement and cement extenders which are older than 120 days from date of grinding shall be retested in a laboratory which has Authority Engineer Notice to proceed at the rate of one set of tests for every 200 tonnes or as otherwise directed by the Authority Engineer and at monthly intervals thereafter.

3.6.3 Aggregates

Aggregates from natural sources shall be in accordance with IS: 383. The Contractor shall submit to the Authority Engineer certificates of grading and compliance for all consignments of aggregate for Notice to Proceed. In addition, at site from time to time, the Contractor shall allow for carrying out such tests and for supplying test records to the Authority Engineer. Aggregates shall be produced by crushing, screening, washing and procured from sources only that have Authority Engineer Notice to Proceed.

For fair faced concrete, the Contractor shall ensure that aggregates are free from iron pyrites and impurities, which may cause discoloration. Aggregates shall be stored on paved areas in different compartments according to their nominal size.

Fine Aggregate:

The Contractor shall provide complete facilities at site for determining grading of aggregates by sieves as per IS: 383, IS: 460, IS: 1607, and IS: 2386.

Only the product of the secondary crusher will be acceptable, subject to conformity with IS: 383. To achieve an acceptable particle, shape the fine aggregate shall be manufactured using crushers specially adapted (Rollobar or similar) to suit the type of material available. Stone

dust or grit from the stone quarries should not be considered as of acceptable quality.

It shall be free from clay, loam, earth or vegetable matter, salt or other harmful chemical impurities. It shall be clean, sharp, strong, angular and composed of hard siliceous material.

The fine aggregate shall be river sand, manufactured sand of appropriate grading. Sand dredged from sea; creeks will not be used. Sand shall be washed and screened to remove any organic matter and clay. RMC manufactured with sand dredged from sea/creek will not be used.

The grading of fine aggregate when determined as described in IS: 2386 (part I), shall be within the grading zones I, II, III.

The Contractor shall provide complete facilities at site for carrying out the following tests:

i. Proportion of clay, silt and fine dust by sedimentation method as per IS: 2386 part II.

ii. Moisture content in fine aggregate as per IS: 2386 Part III.

iii. Bulk density / Bulkage.

iv. Specific Gravity

Coarse Aggregate:

The coarse aggregate shall be crushed stone, natural gravel or a suitable combination thereof. Coarse aggregate obtained from crushed or broken stone shall be angular, hard, strong, dense, durable, clean and free from soft, friable, thin plate, elongated or flaky pieces and any deleterious material.

The grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in correct proportions as and when required.

All coarse aggregate shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386, Parts I to VIII.

The maximum size of coarse aggregate shall be such that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of formwork. Unless otherwise permitted by the Authority Engineer the nominal maximum size shall not exceed 40mm.

Alkali reactive materials:

The aggregates shall be evaluated to identify any minerals known to have a potential to cause alkali silica, alkali silicate, alkali carbonate or any other damaging chemical reaction between alkalis and aggregates. The minerals present should be determined in accordance with ASTM C294 and C295 on a range of samples selected to include every mineral type present in the aggregate as a whole irrespective of the proportion of the mineral.

The aggregate shall be kept clean at all times. The sand equivalent when tested in accordance with ASTM D2419 of the fine aggregate shall be greater than 80. The sand equivalent of the zero to 4.75 fractions of all aggregates shall be greater than 75.

Ethylene glycol tests shall be carried out by the Contractor.

Petrographic examination shall be carried out in accordance with ASTM or standard procedures to identify the minerals present and in particular the percentage of clay minerals.

Chlorides:

The chloride content shall not exceed 0.03% by mass expressed as chloride ion when tested in accordance with relevant standard.

Sulphates:

The Sulphate content shall not exceed 0.4% by mass expressed as SO3 when tested in accordance with relevant standard.

Total Chloride and Sulphate Content:

The total chloride content arising from all ingredients in a mix including cement, water and admixtures shall not exceed the flowing limits, expressed as chloride ion as a percentage of the mass of cement in the mix:

For reinforced concrete 0.1% in 95% of all test results providing no result is 0.25%. The total sulphate content expressed as SO3 of all the ingredients in a mix including cement, water and admixtures shall not exceed 4.0% of the mass of cement in the mix.

Testing:

(a) Acceptance Testing:

As soon as the first aggregates have been produced to stockpile the Contractor shall carry out tests. The method of sampling shall be in accordance with IS: 2430-1969. The amount of material required for each test shall be as specified in the relevant method of test given in IS: 2386 (Part I) – 1963 to IS: 2386 (Part VIII) – 1963.

All tests shall be carried out as described in IS: 2386 (Part I) – 1963 to IS: 2386 (Part VIII) – 1963.

If at any time a significant physical or chemical change in the nature of the coarse or fine aggregate occurs, or a new source of aggregate is used, the Authority Engineer may direct that some or all of the acceptance testing is repeated.

(b) Routine Testing:

The Contractor shall carry out routine testing of aggregates for compliance with the Specification during the period in which concrete is being produced for the Works. The tests set out below shall be performed on aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to the concrete batching plant provided that no set of tests shall represent more than 250 tonnes of fine aggregate nor more than 500 tonnes of coarse aggregate and provided also that the aggregates are of uniform quality. If the aggregate from any source is variable, the frequency of testing shall be as instructed by the Authority Engineer.

Blending of aggregates:

In order to obtain optimum workability, individual aggregates of nominal size 20mm, 10mm,

4.75mm and 2.36mm will be blended in such a way that the grading curve for all aggregates will be a smooth curve from size 0.15mm to 40mm falling within the established envelop grading curve. Contractor shall establish envelop grading curve for each grade of concrete for given maximum size of aggregates for Notice to Proceed before finalising the mix design.

Admixtures:

Chemical admixtures are not to be used until Authority Engineer 's Notice to Proceed. In case their use is permitted, the type, amount and method of use of any admixtures proposed by the Contractor shall be submitted to the Authority Engineer for Notice to Proceed. The minimum cement content specified shall not be reduced on account of the use of the Admixtures.

The Contractor shall further provide the following information concerning each admixture to the Authority Engineer :

i) Normal dosage and detrimental effects if any of under dosage and over dosage.

ii) The chemical names & solid contents of the main ingredients in the admixtures.

iii) The chloride content, if any, expressed as a percentage by weight of admixture.

iv) Whether or not the admixture leads to the entrainment of air when used in the manufacturer's recommended dosage.

v) Where two or more admixtures are proposed to be used in any one mix, the manufacturer's written confirmation of their compatibility.

In reinforced concrete, the chloride content of any admixture used shall not exceed 0.1 percent by weight of the admixture as determined in accordance with IS: 6925 and the total chloride and sulphate contents in concrete mix shall not exceed 0.10 and 4.0 percent respectively by weight of cement.

The admixtures when used shall conform to IS: 9103, ASTM C-494 or AASHTO M-154 or BS EN 934-2 and BS EN 480-10. The suitability of all admixtures shall be verified by trial mixes.

The addition of calcium chloride to concrete containing embedded metal will not be permitted under any circumstances.

Retarding admixtures when used shall be poly hydroxyl compounds or as Notice to Proceed by Authority Engineer.

Air-entering agents shall comply with ASTM C-260 or AASHTO M-194 or BS 5075. Each batch/ consignment shall be tested for specific gravity & performance in concrete before their use.

3.6.4 Batching Plants, Mixers and Vibrators:

(1) For all structural concreting work on the Project, the Contractor shall provide automatic weigh-batching plant of suitable capacity. The plant used shall conform to IS: 4925.

(2) The Contractor shall provide Concrete mixers (IS: 1791 – Batch type concrete mixers, IS: 2438 – Roller Pan Mixer) and Vibrators (IS: 2505 – Concrete Vibrators Immersion Type, IS: 2506 – Screed board concrete vibrators, IS: 4656 – Form Vibrators for Concrete) supplied by recognised manufacturers.

3.6.5 Permeability Test for Concrete

Authority Engineer shall not give a Notice to Proceed without satisfactory test of Permeability by IS 3085 or DIN 1048 (Part – I) tests. Regular permeability tests shall be carried out as per frequency specified by relevant standards.

From the batches thus selected two concrete cylinders shall be made in accordance DIN 1048.

All cylinders shall be made, cured, stored, transported and tested in accordance with DIN-1048 Specifications. The tests shall be carried out in the site laboratory or off site laboratory.

At least two cylinders shall be made on each day's concreting until 60 cylinders have been made for each grade of concrete.

3.6.6 Acceptability Criteria:

Rapid Chloride Penetration Test (RCPT)

RCPT shall be carried out as per ASTM-C-1202 under controlled conditions and by trained technicians. The necessary equipment shall be installed at site laboratory or off-Site laboratory with Authority Engineer Notice to Proceed. The RCPT values should not be more than 1000 Coulombs.

3.6.7 Batching of Concrete Ingredients:

All concreting shall be either produced in automatic weigh batching plant installed at site or Ready-Mix Concrete manufactured in automatic weigh batching plant. The Contractor shall identify reputed RMC Manufacturers and submit to Authority Engineer for Notice to Proceed.

Batching Plant shall be properly maintained and calibrated at a regular interval. The frequency of the calibration shall be as specified by the relevant standards.

3.6.8 Placing temperatures:

During extreme hot weather, the concreting shall be done as per procedures set out in IS: 7861, Parts I & II. The concrete temperature shall not be more than 32oC at time of placing. In hot weather with temperature exceeding 40-degree C, the stock piles of fine and coarse aggregates for concreting shall be kept shaded from direct rays of sun and the concrete aggregates sprinkled with water for a sufficient time before concreting in order to ensure

that the temperature of these ingredients is as low as possible prior to batching. The mixer and batching equipment shall be also shaded and if necessary painted white in order to keep their temperatures as low as possible. The placing temperature of concrete shall be as low as possible in warm weather and care shall be taken to protect freshly placed concrete from overheating by sunlight in the first few hours of its laying. The time of day selected for concreting shall also be chosen so as to minimise placing temperatures. In case of concreting in exceptionally hot weather the Contractor in his discretion specifies the use of ice either flaked and used directly in the mix or blocks used for chilling the mixing water from Chiller plant. In either case, the Contractor shall not be paid extra for cost of ice, additional labour involved in weighing and mixing etc. All salt and saw dust shall be removed from ice before use.

Quality of water used for making ice shall confirm to IS: 456. A complete record of concrete temperature shall be maintained and made available to Authority Engineer. The temperature shall be recorded both at the mixing & placing point.

3.6.9 Transporting, Placing, Compacting and Curing:

General:

Transporting, placing, compacting and curing of concrete shall be in accordance with IS: 456.

Transporting:

The mix after discharging from the mixer shall be transported by agitating transit mixers, buckets, pumps etc. or as Authority Engineer Notice to Proceed without causing segregation and loss of cement slurry and without altering its desired properties with regard to water cement ratio, slump, air content, cohesion and homogeneity. It should be ensured that the concrete is moved to its final destination, placed and compacted before initial set.

The transportation is to be done by agitating transit mixers, pumps or other approved methods.

Placing:

The method of placing shall be such as to prevent formation of cold joints, adulteration, segregation or loss of ingredients. The thickness of horizontal layers shall not exceed 300mm. High velocity discharge of concrete causing segregation of mix shall be avoided. The concrete shall be placed in the forms gently and not dropped from a height exceeding 1.5m. Each layer of concrete shall be compacted fully before the succeeding layer is placed and separate batches shall follow each other so closely that the succeeding layer shall be placed and fully compacted before the layer immediately below has taken initial set.

Concreting of any portion or section of the work shall be carried out in one continuous operation and no interruption of concreting work will be allowed.

Compaction

Concrete shall be fully compacted by Noticed means during and immediately after placing. It shall be thoroughly worked against the formwork, around reinforcement and embedded fittings without displacing or distorting them, and into corners, in order to form a solid mass free from voids.

The concrete shall be free from honeycombing and planes of weakness.

Concrete shall not be subjected to disturbances by vibration within 4 to 24 hours after compaction. Concrete can be compacted by means of external vibrators and in exceptional cases, by internal vibrators. For external vibration, the design of the segment moulds and positioning of vibrators shall be such that efficient compaction and avoidance of surface blemishes is ensured. Internal vibrators shall be rubber tipped and be capable of producing not less than 10,000 cycles per minute.

The Contractor shall ensure that vibrators are operated at pressures or voltages not less than those recommended by the manufacturer in order that the compactive effort is not reduced. Vibration shall be applied by experienced operators only, who shall be under the direct

supervision of an experienced concrete supervisor at all times. Sufficient standby vibrators shall be held available for immediate use in case of breakdowns. A sufficient number of vibrators shall be operated to enable the entire quantity of concrete being placed to be vibrated for the necessary period and, in addition, standby vibrators shall be available for instant use at each place where concrete is being placed.

Internal vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing which shall not exceed the distance from the vibrator over which vibration is visibly effective and, in any case, shall not exceed 600 mm.

Internal vibration shall not be applied by way of reinforcement nor shall vibrators be allowed to touch formwork or reinforcement, or other embedded items as far as is practicable.

Special attention shall be given to the compaction of concrete behind embedded items and in all places where high concentrations of reinforcing steel occur.

The concrete shall be compacted by use of appropriate diameter vibrator by holding the vibrator in position until:

i. Air bubbles cease to come to surface.

ii. Resumption of steady frequency of vibrator after the initial short period of drop in the frequency, when the vibrator is first inserted.

iii. The tone of the vibrated concrete becomes uniform.

iv. Flattened, glistening surface, with coarse aggregates particles blended into it appears on the surface.

v. To secure even and dense surfaces free from aggregate pockets, vibration shall be supplemented by tamping or tamping by rods in the corners of forms and along the form surfaces while the concrete is plastic.

vi. A sufficient number of spare vibrators shall be kept readily accessible to the place of deposition of concrete to assure adequate vibration in case of breakdown of those in use.

vii. Form vibrators whenever used shall be clamped to the sides of formwork and shall be positioned such that the efficient compaction and avoidance of surface blemishes is ensured. The formwork must be made specially strong and watertight where this type of vibrator is used. Care must be taken to guard against over vibration especially where the workability of the concrete mix is high since this will encourage segregation of the concrete.

3.6.10 Curing

1) Segments shall not be de-moulded until the concrete has achieved sufficient strength to prevent damage to the segments during the de-moulding process.

2) Secondary curing of segments is to be initiated immediately following initial stripping of the moulds. The segments are to be maintained for 7 days at a minimum of 100 % humidity, under cover prior to stacking and placing in the stockpile.

3) Curing of concrete shall be complete and continuous using potable water, free from chlorides and sulphates and other requirements as stated in IS 456.

4) Immediately after compaction and completion of any surface finishes the Contractor shall protect the segment from the evaporation of moisture by means of polythene sheet, wet Hessian or other material kept soaked by spraying. As soon as the concrete has attained a degree of hardening sufficient to withstand surface damage, moist curing shall be implemented and maintained for a period of at least 21 days after casting.

5) Method of curing and their duration shall be such that the concrete will have satisfactory durability and strength and members will suffer a minimum distortion, be free from excessive efflorescence and will not cause undue cracking in the works by shrinkage.

6) Steam curing with approved methodology may be adopted if required.

7) Curing compounds may be permitted with Authority Engineer 's Notice to Proceed. However, it is required to be proved that using curing compound the concrete shall not have less strength than concrete cured by water curing. It shall not leave any discolouration on the structural concrete and should not be detrimental to durability of concrete.

3.6.11 Handling and Storage:

The precast units shall be stored under cover prior to stacking and placing in the stockpile. The area intended for the storage of precast units should be surfaced in such a way that no unequal settlement can occur.

To prevent deformation of slender units, they should be provided with supports at fairly close intervals and should also be safeguarded against tilting. Lifting and handling positions should conform to the requirements. In addition, location and orientation marks should be put on the members, as and where necessary. During erection the precast units should be protected against damage caused by local crushing and chafing effects of lifting and transport equipment

3.6.12 Cracks

Cracks, which in the opinion of the Authority Engineer may be detrimental to the stability, strength, durability or structural integrity of the works, the Contractor, at no additional cost to the Contract shall perform sufficient tests as necessary and furnish an Authority Engineer with a report. On evaluation of the report, the Authority Engineer may request remedial works to be taken. Any remedial works shall be at no additional cost to the Contract.

3.6.13 Defective Concrete Segments

Precast concrete segments damaged by improper curing, stripping, storage, handling or any other cause or any which are honeycombed, homogeneous, dimensionally incorrect, or have surface finish or feature defects outside those required by these Specifications, may be classed as defective shall not be used in the Works. All defective segments shall be at no additional cost to the Authority.

The decision of Authority Engineer in this regard shall be binding on the Contractor. Repair of defects:

If on stripping the precast segment moulds the concrete surface is found to be defective in any way, the Contractor shall make no attempt to remedy such defects prior to inspection and the receipt from Contractor Quality Department.

3.6.14 Concrete Finishes

The surface of concrete on which forms had been fixed while concreting shall be classified as follows:

Formed Surface: Allowable deviation from plumb or level dimensions shown on the drawings and from the alignment profile, grades and is defined as "tolerance" and is to be distinguished from irregularities in finishes as described herein. Tolerances in concrete construction are specified elsewhere.

The classes of finish and requirements for finishing of concrete surface shall be as shown on the drawings or as hereinafter specified.

Completed concrete surface shall be tested, where necessary to determine whether surface irregularities are within the limits specified hereinafter.

Surface irregularities are classified as "Abrupt" or "Gradual". Offsets caused by displaced or misplaced form sheathing, or form sections or by loose knots or otherwise defective timber form will be considered as abrupt irregularities and shall be tested by direct measurements. All other irregularities shall be considered as gradual irregularities and will be tested by use of template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template shall be 150cm for testing of formed surfaces and 300cm for testing of unformed surfaces.

The classes of finish for formed concrete surfaces are designated by one of the symbols F1, F2, F3 and F4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

Finish F1: This finish applies to surfaces where roughness is not objectionable, or surface that will otherwise be permanently concealed. Surface treatment shall be the repair of defective concrete, correction of surface depressions deeper than 25 mm and filling of tie rod holes. Form sheathing will not leak mortar when concrete is vibrated. Forms may be manufactured with a minimum of refinement.

Finish F2: This finish is required on surfaces permanently but not prominently exposed to public view for which other finishes are not specified except F1. Forms shall be manufactured in a workmanlike manner to the required offsets or bulges. Surface irregularities shall not exceed 5mm for abrupt and 8mm for gradual irregularities measured with a 1.5m template.

Finish F3: This finish is required for coarse textured concrete surfaces intended to receive plaster, stucco or wainscoting. Surface irregularities shall not exceed 5mm for both abrupt and gradual irregularities.

Finish F4: This finish is designated for surfaces prominently exposed to public view where appearance is also of special importance. This shall include decorative features on the building structures and retaining structure supporting the ramp embankment. To meet with requirements for F4 finish, forms shall be manufactured in a skilful, workmanlike manner, accurately to dimensions. There should be no visible offsets, bulges or misalignment of concrete. Abrupt and gradual irregularities shall not exceed 3mm. Irregularities exceeding this limit shall be reduced by grinding to a level of 1:20 ratio of height to length. Jute bag subbing or sand blasting shall not be used.

Unformed Surfaces:

The classes of finish for unformed surfaces are designated by symbols U1, U2, U3 and U4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

Finish U1: This finish applies to unformed surfaces that will be concealed permanently or otherwise where a screeded surface finish meets the functional requirements. Finish U1 is also used as the stage of finishes for U2 and U3. Finishing operations shall consist of sufficient levelling and screeding to produce an even uniform surface. Surface irregularities shall not exceed 10mm.

Finish U2: This is floated finish, and used on all outdoor, unformed surfaces. Finish U2 is also used as the second stage of finish for U3. Floating to be performed manually or mechanically on stiffened screed surface shall be minimum to produce textured surface. If finish U3 is to be applied, floating shall be continued till a small amount of mortar without excess water is brought to the surfaces so as to permit effective trowelling. Surface irregularities shall be removed as directed by the Authority Engineer.

Finish U3: This is a trowelled finish and shall be used for tops of parapets, etc prominently exposed to view. When the floated surface has hardened sufficiently, steel trowelling shall be started. Steel trowelling on hardened, floated surface shall be performed with firm pressure to produce a dense uniform surface free from blemishes and trowel marks and having slightly glossy appearance. Surface irregularities shall not exceed 5mm.

Finish U4: This is a steel-trowelled finish, similar to finish U3, except that light surface pitting and light trowel marks such as obtained from the use of machine trowelling will be acceptable, provided that surface irregularities do not exceed the limits specified for finish U3.

3.7.16.1 Exposed Concrete Work

Exposed concrete surfaces shall be smooth and even originally as stripped without any finishing or rendering. The Contractor shall exercise special care and supervision of formwork and concreting to ensure that the cast members are made true to their sizes,

shapes and positions and to produce the surface patterns desired. No honeycombing shall be allowed. Contractor shall ensure that no air bubbles are formed on the exposed surface. Concrete pouring sequence, vibration methodology etc. shall be planned to avoid air bubbles.

3.7.16.2 Age of Concrete at Removal of Formwork

Age of Concrete at Removal of Formworks shall be in accordance with CPWD Specifications 96 or IS: 456. The Authority Engineer may vary the periods specified if he considers it necessary. Immediately after the forms are removed, they shall be cleaned with a jet of water and a soft brush.

3.7.16.3 Stripping of Formwork

The work of form work removal should be planned, and a definite scheme of operation worked out. Formwork shall be removed carefully without jarring the concrete and curing of the concrete shall be commenced immediately. Concrete surfaces to be exposed shall, where required be rubbed down with Carborundum stone or bush-hammer to obtain a smooth and even finish. No extra charge will be allowed to the Contractor for such work on concrete surfaces after removal of forms

3.7 Reinforcement

Any steel specified for reinforcement shall conform in every respect to the latest relevant Indian Standard Specifications and shall be of tested quality under the ISI Certification Scheme. All reinforcement work shall be executed in conformity with the drawings and carried out in accordance with the relevant Indian Standard Specifications IS: 2502- Bending and Fixing of Bars for Concrete Reinforcement. The reinforcement steel shall be from primary producers and not re-rolled steel shall be supplied

3.7.1 Storage:

Reinforcement shall be clearly labelled and stored on Site either in racks or on a hard-impermeable base so that it remains straight and free from contamination.

Any reinforcement which is likely to remain in storage for a long period shall be protected from the weather so as to avoid corrosion and pitting. All reinforcement which has become corroded or pitted to an extent, which, in the opinion of the Authority Engineer will affect its properties, shall be removed from Site without delay.

3.7.2 Cutting and bending:

No flame cutting of high-tensile steel bars shall be permitted. Except as provided for below, all bars shall be bent cold and bending shall be done slowly, a steady, even pressure being used without jerk or impact. Reinforcing bars that have been bent shall not be re-bent at the location of the original bend without Authority Engineer Notice to Proceed.

3.7.3 Surface condition:

Immediately before the concrete is placed around the reinforcement, the reinforcement shall be clean, free from mud, oil, grease, paint, loose rust, loose mill scale or any other substance that can have an adverse effect on the steel or concrete or reduce the bond.

3.7.4 Inspection & Testing

Every bar shall be inspected by Contractor before assembling on the Works and any defective, brittle, rusted or burnt bars shall be removed. Cracked ends of bars shall be cut out.

Reinforcement steel shall be fresh, free from corrosion. Corroded steel will not be incorporated in work. If there are traces of corrosion, then the Contractor must give the following treatment to steel for which nothing extra shall be paid. Cleaning of steel by wire brush for removal of dust and rust. No work shall be commenced without the Authority Engineer Notice to Proceed of design drawings. Manufacturer's Certificate shall be supplied for each lot of supply.

Specimens sufficient for three Tensile Tests for each different size of bar for each consignment delivered shall be sampled and tested by the Contractor. Batches shall be

rejected if the average results of each batch are not in accordance with the specifications and shall be removed from Site, without delay.

All manufacturer's test certificates, batch reference labels and quality control certificates shall be retained by the Contractor and noted against each bar mark number at the time of cutting and bending. This information shall be copied to the Authority Engineer weekly.

3.7.5 Bar Bending and Bar Bending Schedule

All bars will be carefully and accurately bent by approved means in accordance with IS: 2502, and relevant drawings. It shall be ensured that depth of crank is correct as per the bar cutting and bending schedule and bent bars are not straightened for use in any manner that will injure the material. Prior to starting bar bending work, the Contractor shall prepare bar bending schedule from the structural drawings supplied to him and get Authority Engineer

Notice to Proceed. Any discrepancies and inaccuracies found by the Contractor in the drawings shall be immediately reported to the Authority Engineer whose interpretation and decision there to, shall be accepted.

3.7.6 Lapping & Welding

As far as possible, bars of the maximum length available shall be used. Laps shown on drawings will be based on the use by the Contractor of bars of maximum length. Payment for reinforcement shall be made only for reinforcement shown in such drawings and such laps. In case the Contractor wishes to use shorter bars, laps shall be provided at the Contractor 's cost in the manner and at the locations that the Authority Engineer Notice to Proceed.

Bars having butt or lap welds shall be provided as specified in the drawings or as Authority Engineer Notice to Proceed.

Mechanical couplings shall be made only by the methods specified and at the positions shown on the Drawings.

3.7.7 Spacing, Supporting and Cleaning

Bars may be welded by Noticed electrical process which does not affect the tensile properties of the bar. Alternatively, the bars shall be bound together with No. 16 gauge, soft annealed wire at sufficient intersections to ensure that the network of bars will retain its designed form, and the network shall be temporarily supported so as to retain its correct position during the process of placing and compacting the concrete. The ends of all such tying wires shall be carefully turned into the body of the concrete and clear of the mould.

Top reinforcement shall be supported on adequate stools to ensure that the reinforcing bars are firmly held in position during concreting.

Normal stools and supports will be detailed on the Drawings and bending schedules. The Contractor shall provide for any additional supporting steelwork to suit his arrangements.

Reinforcement shall be rigidly fixed so that no movement can occur during concrete placing. Any fixings made to the formwork shall not be within the space to be occupied by the concrete being placed.

Cover and spacer blocks required to support the reinforcement shall be as small as possible consistent with their use and be of Noticed design and material.

3.7.8 Projecting ends of ties or clips shall not encroach into the concrete cover.

Cover:

The term "cover" in this context shall mean the minimum clear thickness of concrete between the surface of the reinforcement and face of the concrete.

The minimum cover to reinforcement shall be 40 mm. Cover blocks or spacers required for ensuring that the specified cover is obtained shall be of a material, design and same colour, strength and material source as the surrounding concrete. The blocks shall be formed in specially manufactured moulds and the concrete compacted on a table vibrator, all with Notice to Proceed from Authority Engineer.

The blocks shall be cured in water for at least 7 days. The Contractor shall measure the cover to all reinforcement with a cover meter as soon as the formwork has been stripped and submit the record of this survey to the Authority Engineer as soon as practical. Precast concrete segments with inadequate cover shall be rejected and removed from Site without delay.

3.7.9 Welding

Wherever specified all lap and butt welding of bars shall be carried in accordance with IS: 2571. Only qualified welders shall be permitted to carry out such welding. For cold twisted reinforcement welding operations must be controlled to prevent a supply of large amounts of heat larger than that can be dissipated. The extreme non-twisted end portion shall be cut off before welding. Electrodes with rutile coating should be used. Bars shall be free from rust at the joints to be welded. Slag produced in welding after alternative run should be chipped and removed by brush. Electrode should not be lighted by touching the hot bar. Contractor shall submit welding procedure for Authority Engineer Notice to proceed. All test certificates shall be made to prove the soundness of the welded connection to the Authority Engineer.

3.7.10 Standby Generator

The Contractor shall provide Stand-by generator for emergency case, details of proposals for this system shall be submitted to the Authority Engineer for obtaining his Notice of No Objection.

3.7.11 Noise control

(1) The Contractor shall take all necessary measures to minimise the impact of noise. Such measures shall include:

i) placing of covers over and around the source of noise.

ii) fitting adequately sized mufflers to ventilation and other noise generating equipment.

iii) erecting screens to separate the source of noise from the rest of the working area.

iv) use of electrically powered plant where possible.

(2) The Contractor shall provide a means of measuring the noise level and shall regularly calibrate such equipment. Measurements shall be taken regularly by the Contractor and a full report of readings made shall be submitted to the Authority Engineer within 24 hours. If in the opinion of the Authority Engineer noise levels are unacceptable or there are complaints from the local residents, the Contractor will take additional measures to restrict noise.

(3) The Contractor shall provide suitable ear protectors to his entire workforce and other persons on Site. Zones of risk shall be clearly identified with warning signs.

3.7.12 Hot work

(1) Operations such as conveyor belt vulcanization procedures. Hot work may be undertaken provided the following measures are adhered to:

i) The relevant permits are in place.

ii) Only qualified personnel are permitted to perform hot work.

iii) All gas cylinders underground shall be stored and transported within steel protective cages.

iv) Gas bottles shall be fitted with flashback arresters.

v) A designated fire watch is in place and aware of his duties.

- One dry powder handheld fire extinguisher shall be available at the work location.

(2) A fire watch shall be maintained during burning operations. The fire watch shall have a

fire extinguisher or fire hose readily available. The fire watch shall continue for a minimum of 30 minutes following the cessation of burning operations. When the maintenance teams do not change shift at the work area then all burning operations shall cease 30 minutes before the work area is vacated.

(3) Whenever it is necessary to carry out hot work in a confined space, a specially assigned person shall stand-by throughout the operation at the nearest point of entry. The stand-by person shall be equipped to give prompt assistance in the event of an emergency.

(4) Where stationary transformers are being used, a suitable switch shall be provided close to the equipment which allows for the isolation from the main supply.

3.7.13 Safety notices

The Contractor shall obtain, erect and maintain adequate safety notices for underground work to satisfy statutory regulations and to the satisfaction of the Authority Engineer.

3.7.14 Control of entry

(1) The Contractor shall establish and maintain effective systems to control access to the underground works by all persons. A system utilising the issue and retrieval of tokens or similar method shall be employed. The systems of control used by the Contractor shall obtain a Notice of No Objection from the Authority Engineer. The Authority Engineer reserves the right to withdraw his Notice of No Objection if he is not satisfied that the systems are being applied and enforced adequately.

(2) Where persons not normally engaged on the Works are authorised to enter the underground works, they shall at all times be accompanied by a representative of the Contractor or Authority Engineer.

3.7.15 Compressed air working in cutterhead chamber

The Contractor shall submit for obtaining the Authority Engineer 's Notice of No Objection. A method statement describing the type, capacity and arrangement of plant and medical facilities he proposes to install with full details of his decompression chamber, standby plant, power sources, air cleaning, air cooling plant, bulkhead and locking arrangements. The method statement should also describe the proposed system of signalling, communications and controls to be used in the compressed air operations.

General

(1) The Contractor shall continuously monitor the underground works for the presence of hazardous gas. Should hazardous gas be detected the level shall be controlled by dilution via the ventilation systems.

(2) For this purpose, the Contractor shall supply, use and keep in good order, sufficient equipment and apparatus to comply with the requirements specified hereunder. Where the term methane is used it shall be construed to mean any potentially explosive or hazardous gas.

Ventilation equipment

(1) Ventilation equipment shall be provided in accordance with Clause 4.8.2.4.

(2) In the case of the tunnel boring machine, special attention shall be paid to ensuring that air is directed into areas of the machine and back-up equipment where methane may be trapped, and if necessary auxiliary ventilation equipment shall be provided.

AS-BUILT SURVEY OF ALIGNMENT

3.8.1 Objective

As soon as practicable after the completion of the tunnelling, the Contractor shall carry out an as- built survey of the tunnel alignment. The objectives of the survey are as follows:

(a) To confirm the position of every 5th ring of lining in case of bored tunnel and final support at every 5m in case of NATM tunnel, with respect to the theoretical alignment;

this includes both vertical and horizontal geometry;

(b) To plot the positions of the rings/tunnel profile at points around the circumference(intrados) with respect to their theoretical positions;

(c) To produce an accurate record of the position of the tunnel with respect to the local infrastructure including building, utilities and other sure face physical features;

(d) To verify the finished alignment and profile of the as-constructed tunnel with respect to the theoretical alignment and design profile to ascertain compliance with the Contract provisions in this respect.

3.8.2 Procedure

(1) The Contractor shall carry out the alignment survey and determine the position, with respect to the theoretical tunnel alignment, of the leading edge of every 5th ring of tunnel lining (in case of bored tunnel) and finished tunnel profile (in case of NATM tunnel) at not less than 8 points on the circumference/profile. These shall be as follows:

a) tunnel crown;

b) tunnel invert;

c) axis left;

d) axis right;

e) 45º above axis left;

f) 45º above axis right;

g) 45º below axis left;

h) 45º below axis right.

(2) The Contractor shall take all necessary actions to ensure that the zones where measurements are required are clear of all construction-related obstructions.

Shafts shall be backfilled in layers not thicker than 250 mm each layer being thoroughly compacted with an appropriate compactor. The backfill material shall be homogenous with no material greater than 25mm in diameter. As far as practicable all extraneous materials such as steelwork and temporary timbers shall be removed as the backfilling progresses. Shaft linings shall be left in place to within 2.0mbelow finished ground level and the site reinstated with suitable granular material compacted as specified in Earthworks. Details of temporary works left in place shall be included in the as-built information and drawings. The Contractor ’s methodology for reinstatement of the works, infilling of shafts and adits shall be to the no objection of the Authority Engineer.

4.0 EXECUTION

General

(1) Prior to starting work, all sub-surface services/utilities shall be located and protected and to the satisfaction of the appropriate authorities.

(2) Ground treatment, including any drilling works, shall be carried out with the utmost care to prevent disturbance to the nearby services and property. Care shall be taken to prevent ground loss or heave.

(3) The minimum offset from any drilled hole to a live utility shall be agreed with the respective utility owner and be provided within the method statement.

(4) If the Contractor encounters an unforeseen obstruction, he shall cease drilling and inform the Authority Engineer immediately. The methodology for continuing under such circumstances shall be addressed in the Contractor 's method statement.

(5) The Contractor shall establish suitable temporary benchmarks for the purpose of monitoring ground movements during ground treatment. Such benchmarks shall be outside the zone of influence of the ground treatment.

(6) The Contractor shall monitor ground movements due to ground treatment at least twice a day in accordance with requirements established in the Geotechnical Instrumentation and Monitoring contained herein.

(7) The maximum limit on surface subsidence or heave due to ground treatment shall be 50mm. The Contractor shall establish alarm and action limits to evaluate and modify ground improvement if required.

(8) In the event that surface movements exceed the specified maximum, the Contractor shall immediately stop work and propose alternative treatment methods such as, closer hole spacing, low viscosity grouts, reduced grout pressure, increased relief holes, etc., for the no objection by the Authority Engineer.

(9) If necessary, the Contractor shall inspect all manholes and inspection pits for services within 20 metres, with the permission of the appropriate authority, of any area where injection is taking place to ensure ground modifications effort are not impacting existing facilities.

(10) Inspection of manholes and inspection pits shall take place a minimum of twice per week during the period where ground modification is taking place. Should grouting material be found in any manhole, inspection pit, duct, pipe or other installation, the Contractor shall, under the direction of the Authority Engineer and with the permission of the relevant authority, remove ground modification materials. The Contractor shall propose alternate ground improvement methods to prevent further ground modification materials from accessing adjacent services.

(11) Proving of the improved ground shall be witnessed by the Authority Engineer and conducted from within launch a receiving shaft by measuring the flow from a hole drilled horizontally a distance of 3 metres beyond the outside wall of the temporary shaft. Calculations shall be submitted for the review of the Authority Engineer that correlate the measured flow rate through the probe hole to the estimated permeability of the zone of improved ground. The permeability shall not be greater than 1×10-6 cm/s for tunnel break-in or break-out activities to proceed. Should the permeability be greater than 1×10-6 cm/s, additional ground improvement measures shall be conducted until the permeability is reduced to a level that is acceptable to the Authority Engineer. The Contractor shall allow for all costs associated with testing in his Contract Price. No additional costs in respect of this requirement will be considered.

4.1 GEOTECHNICAL INSTRUMENTATION AND MONITORING

General

(1) The work specified in this section includes furnishing, installing, and monitoring geotechnical instrumentation for all underground works to be constructed, along with existing buildings, structures and services likely to be affected by the Works.

(2) The Contractor is responsible for identifying the zone of influence related to the work and shall determine the amount of additional instrumentation required, and locations to monitor.

Submittals

(1) The Contractor shall submit a Method Statement for the installation and monitoring of the Geotechnical Instrumentation and shall be submitted to the Authority Engineer for non- objection at least 60 days before commencement of instrumentation installation.

(2) The Method Statement shall include at a minimum:

a) Summary of the Contractor ’s methods and calculations use to determine the anticipated zone of influence associated with tunnel and shaft construction

b) Summary of the Contractor ’s assessment of the impact on third party infrastructure and the zone of influence of the works

c) Instrumentation and Monitoring requirements agreed with asset owners and provision

proposed by the Contractor

d) Assessment of which parameters are to be monitored in order to safeguard third party assets and validate the Contractor 's design e.g., ground movement, building/ structure movement, vibration, groundwater levels, etc.

e) The instrument types and specification

f) Planned depths, locations, and detailed drawings for all required and proposed instrumentation

g) The instrumentation layout and monitoring frequency

h) Protection of installed instrumentation, to minimise construction damage

i) The method(s) of instrument installation and calibration

j) Data collection process in the field

k) How data will be stored processed, and interpreted

l) Alarm and Action trigger levels for each class of instrumentation, including justification

m) Relevant Contingency Plans in response to when an Alarm or Action level has been exceeded

n) Flow chart identifying responsibilities and actions of key site personnel with contact details for key site staff in the event that an Alarm or Action level is exceeded

o) Proposal for group meetings to discuss instrumentation requirements and results, frequency of the meetings, and list of required attendees

p) All third-party interfaces confirming, name, organization, role, contact details and asset.

(3) The Contractor shall develop and implement a Movement and Settlement Control Plan to protect existing facilities, tunnels, utilities, structures, roads, streets, and other improvements from damage due to settlement or heave resulting from tunnel construction.

a) The plan shall be submitted for no objection to the at least 60 days before commencement of instrumentation installation.

b) The plan shall include the specific tunnelling methods that will be used to minimize loss of ground, procedures and instrumentation used for monitoring for loss of ground as specified herein, and ground improvement plans.

Quality Control

(1) The Contractor shall engage a professional, geotechnical instrumentation and monitoring firm, acceptable to the Authority Engineer to carry out the instrumentation and monitoring program. The responsible person shall have a minimum of 10 years' experience in geotechnical instrumentation and monitoring and his CV shall be submitted to the Authority Engineer for non- objection.

(2) The Contractor shall provide the following Survey Methods and Survey Control:

I. The Contractor shall establish deep cased bench marks from the approved datum for use in instrumentation monitoring.

II. The Contractor shall establish the elevations of deep cased bench marks by running level circuits started and closed at the specified bench mark and as follows:

a) Establish turning points so that foresights and back sights are approximately equal. Foresights and back sights shall be less than 60 m.

b) Turning points shall consist of well-defined surface points of solid objects or masonry nails driven into pavement.

c) Each error of closure shall be less than 0.3 mm. If any error of closure is greater than 0.3 mm, re-survey the circuit.

d) Prove the established elevations of deep cased bench marks by running at least three separate and complete level circuits which yield consistent results. Re-survey all level circuits until correct and repeatable elevations are obtained.

III. The Contractor shall determine initial locations and elevations of all monitoring points, instruments, and bench marks by optical surveying techniques.

IV. The Contractor shall prove initial readings of facility monitoring points by conducting at least three separate and complete sets of optical survey readings on each instrument which yield consistent results (plus or minus 0.3 mm).

(3) The Contractor shall provide the following for calibration:

(i) Calibrate all gauges and other instruments used for monitoring before use and provide copies of the calibration certificates to the Authority Engineer.

(ii) Calibrate all gauges and other instruments used for monitoring at appropriate time intervals and provide copies of the calibration certificates to the Authority Engineer.

(iii) Operation Requirements: All monitoring instrumentation shall be strong, durable, watertight, corrosion resistant, and able to remain stable under extreme temperature changes from 0 degree C to 60 degrees C.

(4) Testing:

(i) The Contractor shall demonstrate in the presence of the Authority Engineer within 7 days of installation that the instrumentation is functioning correctly. Demonstrate that the central tube of any piezometer or inclinometer is clear to the full design depth. Perform rising and falling head permeability tests on all piezometers and an initial survey of inclinometer tubes to provide a baseline and to demonstrate that the tubes are clear.

(ii) During construction operations, the Contractor shall periodically demonstrate continued proper functioning of each standpipe piezometer by performing rising or falling head tests on a schedule approved by the Authority Engineer.

4.16 Blasting

These specifications shall be applicable for cut and cover and open ramp construction work, wherever permitted by the Authority Engineer.

a) Not less than 40 days prior to commencement of rock excavation in each area, the Contractor shall submit, for review by the Authority's Representative, details of the drilling and blasting methods which he intends to use in that area. If, at any time in a specific area, a plan which has been previously adopted does not these Specifications, the Contractor shall submit a revised plan to the Authority's Representative before continuing excavation in adjacent areas.

b) The Contractor shall develop controlled blasting techniques, which will satisfy the excavation requirements specified herein. In each different type of rock conditions, the Contractor's initial blasts shall be performed as trials, and the burden, drill hole pattern and depth, explosive type and quantity,· blasting sequence and drill delay pattern shall be modified to achieve the requirements specified herein.

c) Blasting means have to follow the licensing requirements and orders as well as the manufacturer's instructions.

d) Blasting operations shall be carried out only under the direction of an experienced operator. The Contractor shall appoint one competent person to be responsible for the security of explosives.

e) Blasting shall be carried out carefully so as to avoid loosening or shattering rock beyond the required line of excavation, and loose or shattered rock (where it does not contribute to stability of the excavation) shall be removed by scaling down or other means before personnel will be permitted to restart operations after blasting.

f) Notices of blasting operations shall be posted on site. Before each firing, the Contractor shall give audible warning, clear the area and shall take positive measures to prevent personnel from entering the danger area.

g) The Contractor shall monitor the results of the blasting closely and, where it is proper to do so, shall propose changes to his blasting operation for the agreement of the Authority's Representative.

h) Under no circumstances shall any holes be charged until completion of all drilling operations at the face.

i) After each blasting operation the tunnel drive shall be sufficiently ventilated to remove any nitrous gases and the atmospheric conditions shall be constantly checked prior to personnel accessing the excavated face.

j) No person shall be allowed to approach the face and no face operation shall commence until the Contractor's authorized person in charge of the operation has given permission after blasting round.

k) As soon as practicable after blasting and without undue delay the Contractor shall erect such support as may be necessary to safeguard the excavation and personnel.

I) The shot-firer must keep a record of the number of shots fired, their time of firing, type and weights of explosives used, and the type and number of detonators used, together with a record of the post-blast situation for each and every location. A copy of the record shall be available to the Authority's Representative at the end of every shift on which shots are fired.

SECTION – 4

General Specifications

4 GENERAL

4.1 Introduction

These Specifications contained herein shall be read in conjunction with other Contract Documents.

The Indian and International Standards as scheduled below have been used as base for the specifications. The Outline Construction Technical Specifications are also based on latest edition of "Specifications for Road works" of Ministry of Road Transport &Highways (MORTH) as published by Indian Roads Congress. The Contractor shall be responsible for detailing in his specifications submitted to the Authority Engineer, as part of the Definitive Design Submission, the standards on which his materials and workmanship will be based. These shall be of similar or higher standard than those listed below. The Contractor is required to Notice in the first instance the Indian Standards and base the specifications on Indian Standards to the extent that they are applicable.

Alternative or additional codes and standards proposed by the Contractor shall be internationally recognised codes and shall be equivalent to or better than, Indian Standards issued by the Bureau of Indian Standards or any other Indian professional body or organisation, subject to being, in the opinion of the Authority Engineer , suitable for incorporation or reference into the specifications. The specifications have been divided into different sections / sub-heads for convenience only. They do not restrict any cross-references. The Contractor shall take into account inter-relations between various parts of works/trades. No claim shall be entertained on the basis of compartmental interpretations.

This Section covers Construction Specifications for all civil structures under the scope of this Contract.

4.2 Storing of Materials at site

a. All materials used in this Design and Build Project shall be stored on racks, supports, in bins, silos, godowns, under cover etc as appropriate to prevent deterioration or damage from any cause whatsoever to the entire satisfaction of the Authority Engineer.

b. The storage of materials shall be in accordance with IS 4082 "Recommendation on stacking and storage or construction materials on site" and as per IS 7969 "Safety code for handling and storage of building materials".

c. The materials shall be stored in a proper manner at places at site agreed by the Authority Engineer Should the place, where material is stored by the Contractor, be required by the Authority for any other purpose, the Contractor shall forthwith remove the material from that place at his own cost and clear the place for the use of the Authority within the time as communicated by the Authority Engineer and at no extra cost to the Authority.

4.3 Materials

All materials shall be of best quality and shall conform to relevant code of practice and manufacturer's specification. Wherever, no specific code of practice of IRC/BIS is applicable, the decision of the Authority Engineer shall be final and binding.

4.4 Workmanship

All works shall be true to level, plumb and square and the corners, edges and rises in all cases shall be unbroken and neat. Any work not to the satisfaction of the Authority or the Authority Engineer will be rejected and at the same shall be rectified or removed and replaced with work of the required standard of workmanship by the Contractor at no extra cost.

4.5 Load testing on Completed Structures

(1) During the period of construction or within the defect liability period, the Authority Engineer may at his discretion order the load testing of any completed structure or any

part thereof if he has reasonable doubts about the adequacy of the strength of such structure for any of the following reasons.

a) Results of compressive strength on concrete test cubes falling below the specified strength.

b) Premature removal of formwork.

c) Inadequate curing of concrete.

d) Overloading during the construction of the structure or part thereof.

e) Carrying out concreting of any portion without the prior Noticed by the Authority Engineer.

f) Honey combed or damaged concrete which will affect the stability of the structure to carry the design load, more so in important or critical areas of the structure.

g) Any other circumstances attributable to the Contractor which may result in the structure or any part thereof being of less than the strength or performance required under the Contract.

(2) All the loading tests shall be carried out by the Contractor in accordance with the agreed methods and Standards. Such tests shall be carried out only after expiry of minimum 28 days or such longer period. The structure shall be subjected to a superimposed load equal to the specified superimposed load assumed in the design. This load shall be maintained for a period of 24 hours before removal. During the test, struts strong enough to take the whole load shall be placed in position leaving a gap under the members. The deflection due to the superimposed load shall be recorded by sufficient number of agreed reflectometers capable of reading to an accuracy of 0.02 millimeters and suitably located under the structure.

The structure shall be deemed to have passed the test if the maximum deflection at the end of 24 hours of loading does not exceed the deflection given by the following expressions:

D = 0.001 L2/25 T, where,

D = max deflection due to imposed load only

L = span of the member under load test (the shorter span in case of slabs). The span is the distance between centres of the supports or the clear distance between the supports plus the depth of the member, whichever is smaller. In case of cantilever, this shall be taken as twice the distance from the support to the end and deflection shall be adjusted for movement of the support.

T = depth of member.

If within 24 hours of the removal of the superimposed load, the structure does not recover at least 75% of the deflection under the superimposed load, the test loading shall be repeated after a lapse of 72 hours. If the recovery after the second test is less than 80% of the maximum deflection shown during the second test, the structure shall be considered to have failed to pass the test and shall be deemed to be unacceptable.

(3) In such cases the portion of the work concerned shall be taken down or cut out and reconstructed to comply with the specifications. Other remedial measures may be taken to make the structure secure at the discretion of the Authority Engineer. However, such remedial measures shall be carried out to the complete satisfaction of the Authority Engineer.

(4) All costs involved in carrying out the tests defined in this Clause (including load and integrity test for piles) and other incidental expense thereto shall be borne by the Contractor regardless of the result of the tests. In case of failure the Contractor shall take down or cut out and reconstruct the defective work or shall take the remedial measures, as instructed, at his own cost.

(5) If the load testing is instructed on any grounds other than mentioned in this clause, then the cost of the same shall be reimbursed if the test results are found to be satisfactory.

(6) In addition to the above load tests, non-destructive tests on various elements (except on piles) such as core test and ultrasonic pulse velocity test shall be carried out by the Contractor at his own expense. Such tests shall be carried out by an agency agreed with the Authority Engineer and. The acceptance criteria for these tests shall be as specified by the testing agency or good Authority Engineer ing practice subject to the Notice of the Authority Engineer.

4.6 Structural Work

(1) Unless otherwise specified, only controlled concrete with design mix and weigh batching is to be used for the work.

(2) Minimum cement content for various grades/elements of concrete as specified elsewhere in these specifications, is purely from durability point of view. Larger content of cement shall be provided if required by mix design or as per the requirement of relevant codes.

(3) Mix design using smaller aggregates of 10 millimeters and below shall also be done in advance for the use at the junctions, where reinforcement is congested.

(4) Procedure of mixing the admixtures shall be strictly as per the manufacturer's recommendations.

(5) All the water tanks and other liquid retaining concrete structures shall undergo hydro-testing.

(6) Special benches shall be provided at site for stacking reinforcement bars of different sizes.

(7) Formwork for beams of Reinforced Cement Concrete works shall be designed in such a way that the formwork of the adjacent slabs can be removed without disturbing the props/supports to the beams.

(8) Wherever there are tension/suspended concrete members which are suspended from upper-level structural members, the shuttering/scaffolding of such members at lower level shall be kept in place until such time as the upper level supporting members have achieved the required minimum strength.

(9) The Contractor shall incorporate seismic considerations of anchoring and isolation in the design and detailing of the finishes. The element to be anchored shall have its motion suitably restrained and isolated so as not to be affected by the deformations/vibrations of the building during Construction.

(10) Formwork shall be provided for full height at all locations. Special precautions for such tall formwork shall be taken to ensure its safety and stability.

4.7 Piling

4.7.1 General: - Piling plant and Methods

(1) Not less than 2 weeks before any piling work is commenced the Contractor shall submit to the Authority Engineer for Notice of full details of his proposed piling plant, and detailed method statements for carrying out the Works. Such details shall include where applicable a full description of the piling frame, hammer, helmet and packing, methods of handling, pitching and supporting the piles before and during driving, the proposed driving procedure to obtain the required penetration, or the proposed set and the method of calculation of the specified working load of the piles and such further information as the Authority Engineer may require. Details of casings and concreting methods in respect of any driven or bored cast-in-place concrete piles shall be included in the submission.

(2) The Contractor shall not commence any piling until the plant and methods which he

proposes to use have received a "Notice to Proceed" from the Authority Engineer but such a Notice shall not relieve the Contractor from any of his obligations and responsibilities under the Contract. If for any reason the Contractor wishes to make any change in the plant and methods of working, he shall not make any such change without having first obtained the Authority Engineer 's "Notice to Proceed" for such changes.

(3) Reference shall be made to the following documents regarding matters relating to the safety of piling works BS8004 Code of Practice for Foundations BS5573 Code of Practice for Safety Precautions in the Construction of large Diameter Boreholes for Piling and Other Purposes

4.7.2 Records

The Contractor shall keep complete records of all data as required by the Authority Engineer covering the fabrication, driving and installation of each pile and shall submit two signed copies of these records to the Authority Engineer not later than 24 hours after installation of the piles.

4.7.3 Programme and Progress Report

The Contractor shall inform the Authority Engineer each day of the programme of piling for the following day and shall give adequate Notice of his intention to work outside normal hours and at weekends.

The Contractor shall submit to the Authority Engineer on the first day of each week, or on such other date as the Authority Engineer may decide, a progress report detailing the rate of progress to that date and progress during the previous week and/or period of all main items of piling works.

4.7.4 Setting Out

1. The Contractor shall establish and maintain permanent datum level points, base lines and grid lines to the Notice of the Authority Engineer and shall set out with a suitable identifiable pin or marker the position of each pile.
2. The setting out of each pile shall be given Notice by the Authority Engineer at least one day prior to commencing work on a pile and adequate Notice for checking shall be given by the Contractor.
3. Notwithstanding such Notice, the Contractor shall be responsible for the correct and proper setting out of the piles and for the correctness of the positions, levels, dimensions, and alignment of the piles.

4.7.5 Tolerances

1. **Piles**

a) Piles shall be driven or bored accurately vertical or to the specified rake and the permitted deviation of the pile centre from the centre-point shown on the setting out plan shall not exceed 50 millimetres measured at the working level of the piling rig, or other level to which Authority Engineer has given Notice to proceed.

b) Deviation from specified cut-off level shall be 25 millimetres.

c) The maximum permitted deviation of the finished pile shall be 1 in 75 from the vertical for vertical piles, and for raking piles 1 in 25 from the specified rake.

d) Forcible corrections shall not be made to piles.

e) The manufacturing tolerances for precast concrete piles shall comply with the following requirements.

i. The external cross-sectional dimensions shall be within 0 millimetres and +5 millimetres of the specified dimensions.

ii. The wall thickness of hollows punconcrete piles shall be within 0 millimetres and +25 millimetres of the specified thickness.

iii. There shall be no irregularity exceeding 6 millimetres in a 3 metre length along the face of the pile measured using a 3 metre straight edge.

iv. The centroid of any cross-section of the pile shall not be more than 12 millimetres from the straight line connecting the centroids of the end faces of the piles.

v. The centroid of any cross-section of a hollow pile shall be determined by assuming that the pile has a solid section.

f) The diameter of cast-in-situ piles shall be at least 98% of the specified diameter.

2. Pile caps

a) Variation in dimensions shall be limited to +50 millimetres and –10 millimetres.

b) Misplacement in plan from specified position shall be limited to 15 millimetres.

c) Surface irregularity measured with 3 metre straight edge shall be limited to 5 millimetres.

d) Variation of levels at the top shall not be beyond 25 millimetres.

4.7.6 Disturbances and Noise

1. The Contractor shall carry out the piling work in such a manner and at such times as to minimize noise and disturbance.
2. The Contractor shall take precautions adequate enough to avoid damage to existing utilities and services and adjacent structures.
3. The Contractor shall ensure that damage does not occur to any part of completed piling works and shall submit to the Authority Engineer for Notice his proposed sequence and timing for driving or boring piles having regard to the avoidance of damage to adjacent piles.

4.7.7 Obstructions

If during the execution of the Works the Contractor encounters obstructions in the ground, he shall immediately notify the Authority Engineer accordingly, submit to him details of proposed methods for overcoming the obstruction and proceed according to the Authority Engineer 's Notice.

4.7.8 Drilling Fluid

1. Drilling fluid shall comprise bentonite complying with Specification IS:2720-1965; IS:2911- 1979, Part I Section 2 Appendix A or DFCP 4 of the Oil Companies Materials Association or given Notice by the Authority Engineer and thoroughly mixed with clean fresh water to form a suspension meeting the specification requirements as submitted to and given Notice by the Authority Engineer.
2. The Contractor shall obtain manufacturers' certificates of the bentonite powder consigned to the site giving properties of each consignment and shall submit them to the Authority Engineer prior to commencing the work and whenever required.
3. The temperature of the water used in mixing the suspension shall not be lower than 5○C. Where saline or chemically contaminated groundwater occurs, special precautions to be maintained and brought to the Notice of Authority Engineer. Contractor to ensure and should take Notice to proceed from the Authority Engineer for any modification to the bentonite suspension or perhydrate of the bentonite in fresh water so as to make it suitable for pile construction.
4. The type and frequency of testing drilling fluid and the method and procedure of sampling shall be proposed by the Contractor and subject to Notice by the Authority Engineer prior to commencement of piling work. Such control tests on the bentonite suspension shall be carried out during the course of the piling work.
5. Before concreting a pile, the Contractor shall remove any heavily contaminated bentonite suspension which could impair the free flow of concrete from the tremie pipe.

A sample of the bentonite suspension shall be taken from the base of the boring using a Noticed slurry sampling device and the specific gravity of the suspension should not exceed 1.20 as per standard practice and also as per IS:2911. Consistency of the mud suspension shall be controlled throughout the pouring as well as concreting operations in order to keep the hole stabilized as well as to avoid concrete mixing with the thicker mud suspension.

6. All reasonable steps shall be taken to prevent the spillage of bentonite suspension on the site in areas outside the immediate vicinity of boring. Discarded bentonite shall be removed from the Site without delay and any disposal thereof shall comply with the regulations of all appropriate relevant authorities.

4.7.9 Tension piles and ground anchors

a) Where tension piles or ground anchors are used the Contractor shall ensure that the load is correctly transmitted to all the tie rods or bolts.

b) The extension of rods by welding shall not be permitted unless it is known that steel will not be reduced in strength by welding.

c) The bond stresses of the rods in tension shall not exceed normal permissible bond stresses for type of steel and grade of concrete used.

4.8 Diaphragm Walling

4.8.1 General

1. The recommendations of BS 8004 Code of Practice for Foundation and DIN 4126 Cast-in- situ concrete diaphragm walls; design and construction shall be followed in so far as they are applicable to diaphragm wall construction. Similar Indian Standards for guidance or adoption are; IS 9556, IS 4651 and IS456.
2. The Contractor shall take full account of fact that in some locations the walls may be close to existing structures and/or within a location where headroom is limited.
3. The Contractor shall pay particular attention to safety aspects of the work, employing barriers and covers as necessary.
4. Where diaphragm walls form permanent structures, these shall also comply with all the requirements for reinforced concrete design and construction

4.8.2 Method Statement

1. The Contractor shall submit a method statement giving the full details of materials, plant and operations involved in the construction of diaphragm walls at least 4 weeks prior to the commencement of construction of diaphragm wall. This method statement shall include but not be limited to the following details.

   a) Dimension of walls and lengths of panels.

   b) Design calculation, dimensions and details of guide walls.

   c) Formation of the joints between panels, including sealing the joints and installation of water stop.

   d) Sequence of excavation and concreting of panels.

   e) Methods of monitoring and checking the stability of adjacent buildings, structures properties, pavements, railways, services, utilities road furniture and the like, all termed EBS.

   f) Methods of monitoring and checking the tolerances associated with the diaphragm wall panels.

   g) Methods of monitoring and checking the stability of the diaphragm wall trench.

   h) Mixing, transporting and placing equipment for the bentonite slurry.

   i) the cleaning and re-use of bentonite slurry;

j) Method of disposal of contaminated bentonite slurry.

k) Type, source, chemical and physical properties of the bentonite to be used.

l) Calculations to show that the density of the bentonite and lowest head of slurry are sufficient to maintain stability of the trench, in ground conditions envisaged, to its entire length.

m) Methods of protection to any adjacent structure and utilities existing close to the trench.

2. Construction of diaphragm walls shall not commence until the Contractor ’s proposals have received a “Notice to Proceed” from the Authority Engineer

3. Unless otherwise given Notice to proceed by the Authority Engineer , the construction of panels shall be continuous once excavation has commenced. Excavated panels or part panels shall not be left open at night or during weekends.

4.8.3 Levels of Work

1. Diaphragm walls shall be concreted to the levels shown on Noticed drawings.

2. The effective trimmed final wall levels shall normally be taken as 250 millimetres below top of guide wall when concrete is cast-up to top of trench. If the groundwater table is high and if required cut-off is low and the groundwater table is also at depth, concreting can be stopped at lower level subject to the Notice of Authority Engineer.

3. Any remaining bentonite within the trench shall be displaced off using lean mix concrete, which shall be poured to the top of the guide walls.

4.8.4 Length of Panels

The length of the panels to be concreted shall be defined in the Contractor 's method statement and shall be subject to a “Notice to Proceed” from the Authority Engineer.

4.8.5 Tolerances

1. Construction shall be carried out in accordance with the following normal tolerances, unless otherwise defined by the Contractor 's drawings or procedures.

a) For straight or other specified profile panels, the minimum clear distance between the faces of the guide walls shall be the specified diaphragm wall thickness plus25 millimetres, and the maximum distance shall be the specified diaphragm wall thickness plus 50 millimetres. The guide walls shall be propped as necessary, to maintain these tolerances, and inner guide wall shall be constructed to the line as shown on the drawings.

b) The trench face of the guide wall on the side of the trench nearest to the subsequent main excavation shall be vertical to within 1:200. The wall face shall not vary from a straight line or the specified profile by more than +15 millimetres in 3 metres and shall be without ridges or abrupt irregularities.

c) The plane of the diaphragm wall face to be exposed shall be vertical to within a tolerance of 1:200, relative to a vertical line projected from the base of the guide wall. In addition to this tolerance, 75 millimetres shall be allowed for protuberances resulting from irregularities in the ground excavated beyond general face of the wall.

d) The ends of panels shall be vertical to within a tolerance of1:80.

e) Where recesses are to be formed by inserts in the wall, they shall be positioned within a vertical tolerance of ±75 millimetres, a horizontal tolerance measured along the face of the wall of ±75 millimeters, and a horizontal tolerance at right angles to the face of the wall as constructed of ±25 millimetres measured to the reinforcement cage.

f) The tolerance in positioning reinforcement shall be as follows.

i) Longitudinal tolerance of cage head at the top of guide wall and measured along the trench: ±75 millimetres.

ii) Vertical tolerance at cage head in relation to the top of the guide wall: ±50millimetres.

iii) Lateral tolerance of reinforcement position in the direction across width of the wall; ±25 millimetres.

g) The tolerance in positioning couplers and starter bars for subsequent structural connections shall be as follows.

i) Longitudinal tolerance measured along the trench, ±75 millimetres.

ii) Vertical tolerance, ±50 millimetres.

iii) Lateral tolerance in the direction across width of panel, ±25 millimetres.

h) A minimum cover to main reinforcement shall be 75 millimetres. Minimum clear distance between reinforcement bars shall be 100 millimetres.

i) Notwithstanding the requirements of this subsection the tolerances may be aggregated only to the extent that they do not exceed 250 millimetres.

2. If, during the general excavation, it is detected that the above-stated tolerances have been exceeded, the Contractor shall draw up proposals for remedying or compensating for the defects.

4.8.6 Access

The Contractor shall note the restricted access to portions of the Works and shall satisfy himself that his method of excavation, positioning of equipment, spoil handling, placement of reinforcement cages, stop ends, and concreting can be accommodated within these restrictions.

4.8.7 Reinforcement

1. Reinforcement shall comply with the requirements of Section 2 of this Volume.
2. High strength deformed steel bars and wires for concrete reinforcement conforming to IS 1786- 1985 and structural steel sections conforming to IS 800-1984 shall be used.
3. Structural steel sections shall be inserted into the cage where openings shall be made at subsequent stages.
4. All reinforcement bars and other structural steel section used shall be clean and free from loose mill scales, dust, rust, oils, grease, paint or other coatings which may reduce the bond with concrete.
5. Front and rear of cages shall be marked on Site to identify them during placement, and lifting points and design of lifting lugs shall not cause distortion of the cage.
6. Distance spacers shall be of an agreed type, capable of resisting displacement during cage placement within the trench and shall not entrap slurry during cage placement or concreting.
7. The reinforcement shall be adequately fixed to avoid displacement and to maintain the minimum specified cover during concreting.

4.8.8 Concrete

1. Structural Concrete shall comply with the requirements of Clause 3.7 above.

4.8.9 Bentonite

1. Bentonite for use in the wall support slurry shall be in accordance with the requirements of this Contract.
2. The Contractor shall institute a programme of regular sampling and testing to ensure that the bentonite fluid properties are suitable for use in the Works. In this regard IS:

9556- 1980 shall be used for guidance.

4.8.10 Storage of Bentonite

1. Bentonite shall be stored in dry cool conditions. Particular care shall be taken with bulk storage to prevent balling of bentonite powder due to damp, or deterioration of properties due to damp and heat.
2. A suitable design of hopper cone and bentonite feeding device shall be adopted. IS 4082-1996 shall be used for guidance regarding stacking and storage of construction materials and components at site.

4.8.11 Alternative Materials

1. The Contractor may, subject to the requirements of the Contract, consider and adopt suitable additional or alternative ingredients and additives for the wall support slurry to that of the bentonite specified above. Samples and full details shall be obtained from the supplier and manufacturer of such ingredients.
2. Any such materials shall have no detrimental effect upon the stability of the excavation or concreting, or formed concrete immediate as well as long term.
3. Ingredients to counteract the loss of slurry to the surrounding strata shall be deemed covered by this Section.

4.8.12 Placing Concrete by Tremie

1. Tremie pipes shall be clean, water-tight and with a minimum internal diameter of 200 millimetres.
2. The tremie tube shall extend to the bottom of the trench excavation prior to concreting and care shall be taken to ensure that all bentonite slurry is expelled from the pipe during the initial charging operation. The tremie pipe shall be maintained with a minimum embedment of 2 metres into the concrete to prevent the re-entry of slurry into the pipe.
3. The Contractor shall ensure that an adequate supply of concrete to the tremie is available at all times so that placement is continuous until completion of the panel.
4. The number of tremie pipes per panel shall be in accordance with the method statement. Where more than one tremie pipe is employed during concrete pouring to any one panel, the charging of concrete into the pipes shall be arranged so that it is evenly distributed between the pipes and so that no differential head exists at the concrete/slurry interface over the length of the panel. This level shall be confirmed by soundings taken during the concrete pour.

4.8.13 Stop Ends

1. Stop-ends, inserted before placement of concrete in the panel, shall be clean and have a smooth regular surface. Any shutter release agent shall have no detrimental effect on the finished works. Where stop-ends are inserted in sections, adequate joint connections must be provided to ensure verticality over the whole length.
2. Extraction of stop-ends shall be carried out at such a time and in such a manner that no damage is caused to the concrete placed against them, or to the adjacent soil and structures.
3. Stop-ends shall be adequately restrained to prevent movement during concreting and not be permanently encased in the diaphragm wall

4.8.14 Inserts

Inserts shall be formed at the locations shown in the Contractor 's drawings and in accordance with his method statements and procedures.

4.8.15 Checking and Monitoring

The Contractor shall provide all necessary monitoring instrumentation necessary for the close and continuous checking of the movements and distortions of adjacent ground and

EBS.

4.8.16 Safety and Emergency Procedures

The Contractor shall take all necessary precautions to ensure stability of his excavations and guide walls and shall take all necessary precautions and be responsible for the safety of personnel in the area of operation.

The Contractor shall maintain, available for immediate use, a sufficient quantity of slurry to allow for any sudden loss. The loss continues despite addition of the slurry and stability of the trench be placed at risk, the Contractor shall backfill with lean mix concrete to preserve stability of the trench and ensure safety of adjacent ground and EBS. The cause of the loss of slurry shall be investigated and works shall not recommence until remedial measures have been implemented.

4.8.17 Site Cleanliness

The Contractor shall ensure that the site is cleared of slurry and that surplus or displaced slurry is disposed of safely and without nuisance. All operations shall be conducted in such a manner as to minimize any spillage of slurry over the Site, or accesses thereto.

4.8.18 Obstructions

1. An obstruction is defined as material, the excavation of which hinders normal progress and the existence of which could not have been foreseen.
2. Upon encountering an obstruction, the Contractor shall determine the method to be employed in removing the obstruction and such method shall be subject to the Notice of Authority Engineer

4.8.19 Disposal of Spoil

1. Spoil removed from the excavation shall be separated from the slurry employed in the excavation process. It shall be disposed of as quickly as possible to locations subject to Notice of the Authority Engineer and in such a manner that spillage and annoyance be minimised.
2. Contaminated slurry, not suitable for re-use, shall be removed from the site and disposed of.

4.8.20 Joints

1. All joints shall be fitted with a water-stop covering the full height of the wall.
2. Where concrete is cast against previously completed wall panels, the previously formed concrete shall be cleaned so that solid substances are removed before the joint is formed.
3. When the joint is exposed upon subsequent excavation, the Contractor shall immediately repair any joints which permit jetting or spraying of water or within which solid foreign substances greater than 3 millimetres separate the concrete in adjacent panels.
4. The walls and joints formed shall satisfy water-tightness requirements of this Contract.

4.8.21 Records

The following records shall be maintained and kept for each wall panel and such records shall be available for inspection by the Authority Engineer.

a) Name of work.

b) Panel No and reference drawing number.

c) Date and time of start and finish of panel excavation.

d) Details of any obstructions encountered; time spent and construction method adopted in overcoming such obstructions.

e) Date and time of completion of cage placement.

f) Date and time of start and completion of panel concreting;

g) Length of panel and width and depth of panel from top of guidewall

h) Top of guide wall level and densities;

i) Top level of wall as cast, in relation to top of guide wall at the edges and at the centre.

j) A log of soil type encountered from start to finish of excavation, and of slurry levels and densities.

k) Volume of concrete used and time of any interruptions in concrete supply where these exceed 15 minutes.

l) Volumes of normal and lean mix concrete.

m) Cut-off level of concrete below top of guide wall level.

n) Date, place and time of slurry control tests and results recorded.

o) Concrete test cubes, w/c ratio, slump markings, date and results obtained on testing.

p) Details of reinforcement and cage type.

q) Quantity of slurry removed from site and spoil removed from Site recorded by date.

r) A graph of theoretical and placed concrete volumes with depth.

4.8.22 Disposal of Slurry

Used bentonite or contaminated slurry not suitable for re-use shall be disposed of in water-tight containers. The Contractor may propose alternative means of disposal which shall be subject to Notice of the Authority Engineer.

4.9 Fabrication

(1) The work of fabrication shall comply with the requirements of IS: 800 or other relevant codes of practice Noticed to the Authority Engineer , in accordance with BS-EN 1993: 2006 or ASTM. Fabrication accuracy shall be within the limits detailed in BS-EN 1993: 2006.

(2) All parts assembled for bolting shall be in close contact over the whole surface and all bearing stiffeners shall bear tightly at top and bottom without being drawn or caulked. The component parts shall be so assembled that they are neither twisted not otherwise damaged as specified cambers if any shall be provided. Drilling done during assembling shall not distort the metal or enlarge holes. The butting surfaces at all joints shall be so cut and milled so as to butt in close contact throughout the finished joints.

(3) Cutting shall be done automatically. Hand flame cutting will not be permitted.

(4) The edges and ends of all cut/sheared flange plates, web plates of plate girders, and all cover plates, and the ends of all angles, tees, channels and other sections forming the flanges of plate girders, shall be planed/ground.

(5) Holes for bolts shall be drilled to conform to clause 10 of IS:7215 (1974). Punching of holes will not be permitted. All drilling shall be free from burrs. No holes shall be made by gas cutting process.

(6) All welding for the works shall be carried out by first class welders and shall be in accordance with IS:816, IS:819, IS:1024, IS:1261, IS:1323 and IS:9595. The Authority Engineer may at his discretion order periodic tests of the welder and/or of the welds produced by them. All such tests shall be carried out by the Contractor at his cost.

(7) Safety requirements should conform to IS: 7205, IS: 7273 and IS: 7269 as applicable and should conform to safety, economy and rapidity.

(8) As much work as possible shall be welded in shops. The pieces shall be manipulated to ensure down hand welding for all shop joints as far as possible. All parts to be welded shall be arranged so as to fit properly on assembly. After assembly and before the general welding is to commence the parts are to be tack welded with small fillet or butt welds as the case may be. The tack welding must be strong enough to hold the parts together but

small enough to be covered by the general welding. The welding procedure shall be so arranged that the distortion and shrinkage stresses are reduce to a minimum.

(9) All joints required in structure to facilitate transport or erection shall be shown on the drawings. The lengths of structural shall be the maximum normally available in the market and the jointing of shorter length in order to make up lengths required shall not be permitted.

(10) Each piece of steel work shall be marked distinctly before delivery, indicating the position and direction in which it is to be fixed. Three copies of a complete marking plan shall be supplied to the Authority Engineer before erection commences.

(11) In the case of welded fabrication any distortion remaining in the member after welding operations are completed shall be rectified by and/or at the expense of the Contractor.

(12) All members of trusses and lattice girders shall be straight throughout their length, unless shown otherwise on the drawings, and shall be accurately set to the lines shown on the drawings. Sheared edges of gussets or other members to be straightened and dressed where necessary.

(13) Templates and jigs used throughout the work shall be all steel. In cases where actual materials have been used as templates for drilling similar pieces, the Authority Engineer ’s Notice shall be obtained to use as parts of the finished structure.

(14) Apart from the requirements of welding specified under the above sub clauses, sections above, the Contractor shall ensure the following requirements in the welded joints.

(15) Strength-quality with parent metal.

(16) Absence of defects

(17) Corrosion resistance of the weld shall not be less than that of parent material in an aggressive environment.

(18) No gasket or other flexible material shall be placed between the holes. The holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely placed in position. Driving of bolts is not permitted. The nuts shall be placed so that the identification marks are clearly visible after tightening. Nuts and bolts shall always be tightened in a staggered pattern and, where there are more than four bolts in any one joint, they shall be tightened from the centre of the joint outwards.

4.9.1 Detailing of Connections

(1) Detailing of connections shall ensure that inaccessible pockets/gaps are avoided. In this respect, back-to-back angles with spacers and similar details which would prevent full accessibility for painting are not acceptable.

(2) Where cope holes are required to allow completion of butt welding, they shall be of adequate size to allow fillet welding to seal the connection, while still allowing full accessibility for subsequent painting.

(3) Snipping of stiffeners at the root radii of rolled members is not acceptable. Stiffeners shall be cut to the required profile to fit closely into all such radii, and seal welded.

(4) High-strength friction grip (HSFG) bolts shall be used only on mating surfaces as specified herein.

(5) HSFG bolted connections, slip-bolted connections and welded connections shall not be used interchangeably or in tandem with each other. The use of each of these types of connections shall be separate and distinct.

4.9.2 Submissions

(1) The Contractor shall submit to the Authority Engineer two initial copies of each shop drawing and subsequently four copies of the final shop drawings for retention by the Authority Engineer.

(2) The Contractor shall submit for Notice details of erection procedures. The procedure should contain details of safety precautions to be taken during erection - refer IS 7205.

4.9.3 Welding

(1) Metal-arc welding of steel shall be in accordance with the requirements of relevant IS, BS-EN or ASCI standards.

(2) Run-on/run-off plates shall be used during butt welding.

(3) Fillet welds shall be continuous to form a complete seal where two members join or abut.

4.9.4 Electrodes

Welding consumables shall be suitable for the type of steel and position of welding and shall give a weld deposit with mechanical properties not less than the minimum specified in the relevant welding standards. Hydrogen-controlled electrodes shall be used for butt welding of steel over 25 millimetres thick.

4.9.5 Welders

Welders employed on the work shall be tested to BS 4871 and BS 4872: Part 1. Welding shall be carried out under the supervision of a competent welding technologist and the test pieces shall be tested to BS 4870.

4.9.6 Testing

(1) The Contractor shall make radiographic examination of butt welds in accordance with Section 8 of American Petroleum Industry (API) Standard 1104 and shall carry out dye-penetrant tests in accordance with BS 6443.

(2) Not less than 10% of the length of each butt weld shall be radiographically inspected and 10% shall be tested using the dye-penetrant method.

(3) Not less than 5% of the length of each fillet weld shall be tested using dye-penetrant testing.

4.9.7 Site Welding

(1) The Contractor may, subject to prior Notice, use site welding as an alternative to bolted connections.

(2) Site-welded joints shall be inspected by radiography in accordance with Section 8 of API Standard 1104 or by ultrasonic means when given Notice by the Authority Engineer. Initially 100% of each butt weld shall be inspected. At the Notice of the Authority Engineer , the number of inspections may subsequently be reduced.

(3) Finished welds shall comply with Section 6 of API Standard 1104. Defective welds shall be cut out, remade and retested as Noticed.

4.9.8 Erection of Steelwork

Erection of steelwork shall comply with the requirements of BS-EN 1993: 2006, Stanchions shall be plumbed using steel packs and wedges and restrained while the spaces beneath the base-plates are filled with a Noticed non-shrink cementitious grout. Packs and wedges shall be protected by grout to a minimum thickness of 50mm.

The Contractor shall be responsible for checking the alignment and level of foundation and correctness of foundation bolt centres, well in advance of starting erection work, and shall be responsible for any consequences for non-compliance thereof. Discrepancies if any shall immediately be brought to the Notice of the Authority Engineer.

The structure should be divided into erectable modules as per the total scheme. This should be pre- assembled in a suitable yard/platform and its matching with members of the adjacent module checked by trial assembly before erection.

Immediately prior to erection any rust in the paint area shall be removed by power wire brushing to a standard equivalent to SA3.

During erection the rough handling of fabricated materials such as bending, straining or pounding with sledges shall be avoided. Any damage to the structure during transportation or erection shall be immediately rectified by the Contractor at his own cost. The straightening of bend edges of plates, angles and other sections shall be done by methods which will not cause fracture.

Following the completion of the straightening, the surface of the member shall carefully be inspected for damage before further use.

The Contractor shall be responsible for accurately positioning, levelling and plumbing of all steelwork and placing of every part of the structure in accordance with the Noticed drawings and to the satisfaction of the Authority Engineer. All stanchion base, beam and girder bearings etc. shall be securely supported on suitable steel packs. All reference and datum points shall be fixed near the work site for facilitating the erection work.

All equipment used by the Contractor shall be sufficient for the purpose and for erection of steel work, in the time specified in Contract. Any lifting or erecting machinery shall be noticed to be removed from the site. If the Authority Engineer considers such appliances dangerous or unsuitable for their functions. Notice of Authority Engineer shall not relieve the Contractor from responsibilities for loads to which the erection of equipment shall be called upon to carry out. Adequate arrangement shall be made to resist wind loads and lateral forces arising at the time of erection.

The Contractor is entirely responsible for the stability of the structure during erection and shall arrange that sufficient tack bolts, braces or guy ropes are used to ensure that work will remain rigid until final bolting, riveting or welding is completed. The Contractor shall supply and fix, without extra charge, any temporary bracing which may be necessary.

All steelwork shall be erected in the exact position as shown on the Drawings. All vertical members shall be truly vertical throughout and all horizontal members truly horizontal, fabrication being such that all parts can be accurately assembled and erected. No permanent bolting, welding or grouting shall be done until proper alignment has been obtained and checked.

At stanchion splices and at other positions where concrete cover to the steel is liable to be restricted, bolts will be placed with their heads on the outside of the members.

All field assembly bolting and welding shall be executed in accordance with the requirements for shop fabrication excepting such as manifestly apply to shop conditions only. Where steel has been delivered painted the paint shall be removed before field welding for a distance of at least 50mm on either side of the joints. The number of washers on permanent bolts shall not be more than two for the nut and one for the bolt head.

4.9.9 Tolerances

The tolerances for erected steelwork shall be as shown on the Drawings. In-lieu of other information the tolerances from BS-EN 1993:2006 shall be adopted.

4.9.10 Bolted Connections

(1) Bolts shall be threaded only over the length of shank which is outside the parts bolted together. The bolt shall protrude by at least two complete threads and not more than four complete threads beyond the outer face of the tightened nut.

(2) Holes shall not be distorted or enlarged by the use of drifts.

(3) High strength friction grip bolts shall be fitted in accordance with BS 4604, Part 2.

(4) Load-indicating washers shall be installed in accordance with the manufacturer's recommendations.

4.9.11 Transportation and Storage

Steelwork and protective coatings shall be protected from damage during packing, handling, transportation and storage. The Contractor shall ensure that members are not

subjected to greater stresses than those allowed in BS 5950, Part 2 during fabrication, transportation, storage and erection. Stored items shall not be in contact with each other and shall be clear of the ground.

4.9.12 Damaged Material

Steelwork deemed to be damaged during the Contract period shall be replaced. The Contractor shall provide Noticed by the Authority Engineer for remedial work to damaged material if repairable. The method of repair and final repaired condition shall be obtained a Notice by the Authority Engineer.

4.9.13 Galvanising

(1) Galvanising of steelwork, if required, shall be carried out after fabrication is complete. Steelwork required to be galvanised shall be pickled in dilute hydrochloric acid, washed, fluxed and stoved, and then coated with zinc by dipping in a bath of molten zinc.

Components shall be immersed in the bath only for the period sufficient to attain the temperature of the bath and shall be withdrawn at a speed which ensures that a coating of 610 grams per square metre of surface is achieved – i.e., 85 microns minimum Dry Film Thickness (DFT). Components shall be covered evenly on all surfaces. Items shall not be galvanised in more than one dip event due to potential warping or additional stresses that may be induced in the metal.

(2) Items described as heavily galvanised shall be grit or sand blasted prior to galvanising and shall receive a minimum coating of 1000 gram per square metre of surface – ie,140 microns minimum DFT.

(3) Lightweight gauge metalwork shall be galvanised by the hot-dip process as specified in BS 3083 or BS 2989.

(4) Contact between galvanised steel members and aluminium surfaces or between galvanised and ungalvanized steel members shall be prevented by means of Noticed insulating washers and grommets.

(5) Galvanised steelwork shall be cleaned, degreased and etch primed before application of the specified paint treatment.

4.9.14 Preparation of Steelwork for Protective Treatment

(1) Surfaces shall be cleaned to BS 7079 before any protective treatment is commenced.

(2) Steelwork shall be degreased and shot or grit blasted to Sa 2.5 quality standard with surface amplitude of 50 to 75 microns to remove rust and mill scale. Dust and debris shall be removed by vacuum cleaner, compressed air or brush. Site welds and adjacent steelwork shall be blast cleaned and similarly prepared. Surface defects shall be removed in accordance with BS 5950.

(3) Regular mill scale detection tests shall be made using the Copper Sulphate method.

4.9.15 Painting Generally

(1) Paint shall be applied by brushing or spraying in accordance with the manufacturer's instructions. When permitted, thinners shall be added to paint in strict accordance with the manufacturer's permitted percentages.

(2) Brushes stored in thinners shall be worked to remove thinners before re-use.

(3) Painting shall not be carried out when the steelwork temperature is below 4oC, above 50oC, less than 3oC above the dew point, or when the relative humidity is above 80%.

(4) Stripe coats shall be applied to welds and steel edges before painting.

(5) Strong paint films shall be achieved on all cleats, arises, bolt holes, bolt heads and the like.

(6) Protective treatment, other than the site-applied coatings, shall be applied under factory conditions in an enclosed shop. Completed coats shall be checked for continuity by a low-

voltage wet sponge holiday detector and for thickness by an Elcometer. The colour of each coat shall be sufficiently different to permit detection of incomplete application.

(7) If a required film thickness is specified, it shall be the minimum dry film thickness (DFT) as measured by a Noticed gauge. The gauge shall be calibrated for each coating by the use of a shim placed on the shot blasted blank or on the underlying coat. The shim shall correspond to the theoretical film thickness of the coating to be measured. Otherwise, a full coating shall be applied in accordance with the rate of coverage recommended by the manufacturer, having regard to the surface profile of the steel and the conditions of application.

(8) Sample plates shall be prepared for approval and shall thereafter be adopted as the standard to be achieved in the finished work.

(9) The Contractor shall prevent dust and dirt coming into contact with freshly painted surfaces.

(10) Before the site painting coats are applied, the surfaces shall be lightly abraded, if required by the manufacturer's instructions, and washed with clean water to remove salt and other impurities.

(11) Paint shall not be applied to the embedded portions of metal items except those within 75 millimetres of the finished concrete surface.

4.9.16 Application of Protective Layers

Blast-cleaned surfaces shall be kept dry and shall receive the first coat within 4 hours of the start of cleaning – i.e., 2 hours for outdoor blast-cleaning. They shall be treated in accordance with the protective treatment schedule, except the faying surfaces for high strength friction grip bolt connections.

4.9.17 Protection of Bolts etc.

Bolts, including high strength friction grip bolts, nuts and washers shall be hot-dip spun-galvanised or as Noticed by the Authority Engineer. The threads of nuts may be re-tapped as provided for in BS 729.

4.9.18 High Strength Friction Grip Connections

(1) Faying surfaces for high strength friction grip connectivity shall be blast-cleaned to Sa 2.5 quality standard, masked within two hours to exclude air and exposed just before bolting-up. Paint and other contaminants shall not be allowed on faying surfaces.

(2) Each consecutive coat of paint shall be stepped back from the edge of the faying surface by 15 millimetres.

4.9.19 Protective Treatment

(1) Damaged paintwork shall be blast-cleaned if bare metal is exposed or corrosion is present. If the first coat is intact the surface shall be prepared by power wire brushing. The prepared surface shall be protected with a nominated full paint protection system.

(2) Submerged steelwork shall, in addition, be coated with a compatible chlorinated rubber-based anti-fouling paint to a DFT of 75 microns.

4.9.20 Paintwork Executed on Site

(1) Following erection, the exposed parts of galvanised nuts, washers and bolts (except chain fixing bolts) shall be degreased, etch-primed and painted to the specification for adjacent steelwork. Freshly galvanised surfaces shall be abraded and washed before application of the etch-primer.

(2) After the preceding operations, and prior to the erection of cladding, if any, the Contractor shall apply to the superstructure steelwork the finish coat(s) as specified. Any damage to shop- coats will be made good on site prior to application of the Site coats. If steel has been exposed, then the area shall be blast-cleaned primed and receive all shop-coats or Site-coats to the required standard.

(3) Before the Site-coats are applied, the surfaces shall be lightly abraded, if required by the manufacturer's instructions, and washed with clean water to remove salt and other impurities. Paint shall not be applied to the embedded portions of metal items except those within 75 millimetres of the finished concrete surface.

4.10 RETAINING WALL

4.10.1 General Requirement

(1) Before commencement any construction work, the Contractor shall prepare and submit appropriate survey method statements relating to his proposed methods of working.

(2) The Contractor shall take into consideration all geological and other relevant parameters applicable for the Contract reach.

(3) Drainage treatment behind retaining walls shall be done. In principle, all walls should be provided with weep holes. The weep holes are placed horizontally at the lowest points where free outlets for water may be obtained and should be spaced at not more than 2.0 m center to center in a staggered manner. must be provided with filter material covered with geotextile filter fabric.

For rockfall following counter measures shall be followed by Contractor.

TABLE 6.1: CLASSIFICATION OF COUNTERMEASURES FOR ROCK FALLS

SR. NO.	CLASSIFICATION		TYPE OF WORK
1	Earth Work	Earth work	Removal
			Re-cutting
2	Drainage Work	Surfaced drainage	Drainage Ditches
3	Fixing Work	Supporting	Stone/ Concrete support
		Anchoring work	Anchor/ Rock bolt
4	Slope Protection work	Pitching work	Stone / Concrete block
		Shotcrete work	Mortared/ concrete
		Crib work	Concrete block cribs (Precast)
			Cast in place concrete cribs

4.10.2 Construction of Retaining Walls

Retaining walls should be carefully constructed because these structures are designed to retain the extensive earth pressure and therefore the failure of these structures will result in the severe damage not only to the road facilities but also to the road users.

(A) Foundation Work

The foundation works for retaining walls should be considered as follows:

(1) The bearing ground should be excavated to a depth required for placing a footing if it is bedrock, the excavated foundation surface of bedrock should be cleaned, and then the spread footing should be placed.

(2) If the bearing ground is earth or gravel, rubble stones should be laid over the excavated surface and rolled fully and uniformly, leveling concrete should be poured over the rubble stones, and then the spread foundation should be placed over it.

(3) If the bearing ground is soft and compressible, a pile foundation should generally be applied. In addition, if the soft ground (or stratum) is thin or if replacing material is easily available, the soft ground should be replaced with good quality soils so that the retaining walls may be built directly over the replaced material.

(B) Backfill Work

Backfilling should be not allowed until the retaining structure become stable and strong enough to resist the earth pressure.

(1) Only selected quality materials should be used to backfill the retaining wall.

(2) Compaction is completely required.

(3) Rain water should be completely prevented from flowing into the portion of backfilling.

(4) Drainage facilities must be provided in order to drain the seepage water. Especially weep holes must always be provided with a rate of one weep hole per 2-4 m2 of retaining wall.

In addition, in principle, anti-proof sand treatment behind the walls should be placed between the walls and the back slope or backfilling to prevent the flow out of fine soil from the back slope, and hence preventing from disturbing the stability of soil mass behind the walls.

4.11 Construction of Road Under Bridge (RUB) by RCC Box Pushing Method

This work covers the design, construction, and commissioning of a Road Under Bridge (RUB)/Subway using the RCC box pushing method beneath an existing operational railway track/embankment, ensuring minimum disruption to rail traffic.

Scope of Work

Includes the entire execution cycle—soil investigation, design approvals, construction of thrust/casting beds, RCC box fabrication, box pushing using rail cluster and rolling assemblies, restoration of railway track, construction of approaches, retaining/wing walls, drainage and anti-waterlogging systems, waterproofing, roadworks, and all temporary, protective, and safety arrangements.
Execution shall strictly comply with RDSO and Railway Board guidelines, ensuring minimal traffic blocks and safe speed restoration.

Codes, Standards & Guidelines

- **IRS Codes**: Concrete Bridge Code; Bridge Sub-structure & Foundation Code (Backfilling); IRPWM (blocks, track restoration).
- **RDSO**: BS-137 (pulling/air method), BS-138 (box pushing), standard drawings for thrust bed, rail cluster, rollers, and RCC boxes.
- **Railway Board**: RUB drainage & anti-waterlogging circulars; approved innovative pushing methods.
- **IS / IRC**: IS 456, IS 2062, IS 1786, IS 14687, IRC:37/58 (road crust).

Design Parameters

- **RCC Box**: As per approved GAD; M30 waterproof concrete with admixtures; Fe500D reinforcement; railway loading (25T-2008/DFC); smooth machined haunches.
- **Thrust Bed**: RCC M25 precast base slab with shear keys and pin pockets; SBC adequate for maximum pressure.
- **Earth Cushion**: Minimum 150 mm with bituminous coating over top slab.
- **Barrel Length**: Site-specific with cutting edge for pushing.

Materials & Equipment

- **Concrete**: Controlled batching, w/c ≤0.40, cube/core testing mandatory.
- **Steel**: Fe500D rebars; IS 2062 steel for rail clusters and rolling assemblies with approved welding and NDT.
- **Rail Cluster**: Three nested 52 kg rails.
- **Rolling Assemblies**: 50–150T capacity, FOS ≥1.25, friction 0.05–0.10.
- **Hydraulics**: Jacks ≥1.5× box weight; winches ≥2× calculated pull force, duly calibrated.
- **Waterproofing**: PVC water bars, sealed joints, shotcrete; no weep holes in retaining walls.

Construction Methodology

Pre-Block: Soil investigation, thrust bed casting, RCC box fabrication, trial jacking, installation of rail clusters/rollers, approach preparation.
Block Phase (Railway-controlled): Track dismantling, excavation with shoring, sand bedding, box pushing (≈30 m/hr) with strict alignment control, backfilling, and progressive track restoration with staged speed recovery.
Post-Block: Construction of wing/return walls, road approaches, wearing course, and permanent drainage works.

Drainage & Anti-Waterlogging

Provision of sumps, pumps, sealed retaining walls, humps, perforated drains, soak pits, and waterproof concrete to ensure zero water stagnation, as per Railway Board instructions.

Safety, Traffic & Quality Control

- Detailed block plan, safety protection works, speed regulation as per IRPWM.
- Quality Assurance Plan (QAP) covering material testing, equipment load testing, settlement monitoring, as-built drawings, and approval of all stages by the Authority Engineer.

4.12 BLASTING

4.12.1 General

Excavation Method

(1) The Contractor shall provide to the Authority Engineer full details of the proposed rock excavation methods for Notice to Proceed at least 28 days before the commencement of excavation. Similarly, the Contractor shall submit his plans for methods for monitoring particularly vibration adjacent to the EBS.

(2) Since the area falls under the sensitive buildings and other important premises, Method such as mechanical, pneumatic or hydraulic plants to be used for in rock excavation.

(3) Usage of Blasting or expansive chemical agents etc. are subjected to Authority Engineer ’s issuance of No objection and approval from all the competent authorities for rock excavation.

4.12.2 Definitions

“Controlled blasting” means that a designed drill and charging pattern has been Noticed and will incorporate one of the following techniques.

"Pre-splitting" means drilling a line of closely spaced parallel holes of appropriate diameter along the excavation surface, charging the holes with an appropriate amount of explosive and detonating these holes simultaneously, prior to the main production blast, to shear the rock along the line of drill holes.

"Smooth blasting" means the drilling of a line of closely spaced parallel holes along the excavation surface, with a suitable burden/spacing ratio, loading all the holes lightly with an appropriate amount of explosive and detonating all these charges simultaneously, after the detonation of the main production blast.

4.12.3 General Requirements

(1) All blasting operations shall be conducted under the direction of a certified blaster. Evidence of blaster certification shall be carried by blasters or shall be on file at the Authority Engineer office during blasting operations. The blaster shall be present at the firing of a blast at all times.

(2) A blast design shall be submitted to the Authority Engineer for ‘Notice to Proceed’ prior to any blasting operations. The blast design will include sketches of drill patterns, delay times and blasting mats and shall indicate the type and amount of explosives to be used, critical dimensions, and the location and general description of structures to be protected, as well as an outline of design factors to be used, which protect the public and meet the applicable air blast and ground vibration standards. The Work shall be

programmed so as to minimize blasting adjacent to previously constructed sections of the Works.

(3) Every precaution including the use of blast mats, timber boarding or other means shall be exercised to protect the Works and persons, animals and property in the vicinity of the Site. The Contractor shall accept responsibility for all injury or damage occasioned by any blasting operations and shall make good such damage without any additional payment.

(4) The Contractor shall, in particular, note the requirement that he must limit to the maximum extent practicable the spillage of material from surface excavations, whether by blasting or other means. To this end the Contractor shall take all necessary precautions including, if necessary, covering the rock prior to blasting with sufficient loose material to prevent the blasted material being thrown into the adjacent areas. If the Authority Engineer is of the opinion that insufficient precautions are being taken to minimize the spillage of material, he may instruct the Contractor to adopt further measures to reduce the spillage. No additional payment will be made to the Contractor for any such measures required and extension of time will not be granted.

4.12.4 Use of Explosives

(1) Explosives shall not be used without Notice to Proceed from the Authority Engineer and only after the appropriate permits have been obtained. Notice to Proceed for blasting does not remove the Contractor 's liabilities or responsibilities to ensure that his method of blasting is safe and complies with all statutory and imposed limitations.

(2) A Relevant Authority will issue all blasting permits and related permissions pertaining to storage, transportation, control and use etc. The permits will include local/national requirements and other requirements of the International Fire Code and other international standards for explosive and blasting procedures, explosives training, blaster's handbook and safety practice manual etc. All explosives and related material shall be in conformity with the requirements of the Relevant Authority having jurisdiction and the specifications contained herewith. Blasting will not be permitted close to any building structure without appropriate monitoring systems and no objection from the Authority Engineer.

(3) Both cartridge and bulk explosives may be used where appropriate.

(4) Only sufficient explosives and detonators may be brought on to the Site for immediate blasting requirements. Explosives and detonators remaining unused after each blasting operation shall be disposed of, or removed from the Site.

(5) The Contractor shall appoint a Responsible Person or Persons to order and receive explosives on the Site. The name(s) shall be notified to the Authority Engineer.

(6) No persons other than those authorised by the Authority Engineer shall approach within 50m of the area being prepared for blasting, i.e. during charging and firing of the blast holes. The Contractor shall inform the Authority Engineer of the names of his authorised personnel and his method for excluding other

(7) The Contractor shall provide an agreed system of warning and preparing the general public and all Site personnel of an impending blast by both audible and visual means and shall ensure that the blasting area is cleared of all personnel immediately prior to blasting. This system shall comply with all statutory requirements.

(8) The limits for air-overpressure and vibration monitoring together with actions associated with the alert, alarm and action levels shall be addressed in the Blast Assessment Report/ Method Statement for the Notice to Proceed from the Authority Engineer.

(9) The Contractor shall use a lightning detector on site to assess the potential risk of lightning during delivery, loading and charging blast holes with explosives. The lightning detector shall be capable of detecting thunderstorms.

(10) The Contractor shall check for stray electric current at the blasting site prior to commencing charging.

(11) All blast air, exhaust gases and dust shall be filtered in an agreed manner before being ventilated into the air exhaust system. A detailed method statement will be required for seeking a Notice to Proceed from the Authority Engineer.

(12) Blast partition doors separating the Contractor 's Working Areas from the public and other operational areas shall be of adequate fire protection, water tightness, weight, thickness and density to effectively reduce the noise, water and dust transmitted from the Works and confine the effects of the blast to acceptable levels. The effective damping mass of the partitioning materials shall not be less than 30 kg/m2

4.12.5 Delivery of Explosives

(1) The handling of explosives including storage, transportation and charging will be carried out in accordance with BS 5607, 'Code of Practice for Safe use of Explosives in the Construction Industry' and IS 10386 Part 4 'Handling Storage & Transportation of Explosives'.

(2) The Contractor shall submit his proposal for explosives collection and delivery for Notice to Proceed from the Authority Engineer. The risk assessment for the proposed arrangement shall be addressed in the Blasting Assessment Report.

(3) The Vehicle shall not carry more than 200kg of explosives at any one time or the figures agreed by the Authority Engineer. Upon each delivery of explosives, the Vehicle shall be escorted by the Contractor's appointed Responsible Person(s) and armed guards and as agreed by the Relevant Authority & the Authority Engineer.

(4) The explosive container shall be secured to the body of the Vehicle.

(5) At least two serviceable fire extinguishers shall be installed on the Vehicle.

(6) The Vehicle which has been fitted out to the above requirement is required to be presented for inspection and agreed with the Authority Engineer.

4.12.6 Blasting Risk Assessment

(1) The Blasting Risk Assessment and Blasting Risk Assessment Report shall be undertaken by a qualified Authority Engineer with the Notice to Proceed from the Authority Engineer.

(2) The Blasting Risk Assessment and Blasting Risk Assessment Report shall be carried out in accordance with the procedures submitted to and agreed by the Authority Engineer. The location and size of the blasting trials associated with the Blasting Risk Assessment shall have a Notice to Proceed from the Authority Engineer.

(3) The Blasting Risk Assessment shall evaluate the impact caused by blasting using gradual increase in vibration levels generated by trial blasts, which shall not exceed the specified values in the Contract. Planned vibration target levels generated by the trial blasts shall be obtained by adjusting explosive charge weights at the same time taking into consideration changes in distance, drilling pattern, confinement of the blast and rock condition. The design of explosive charge weights shall be made from linear regression based on previous blasting works. The predicted PPV (not exceeding the specified values in the Contract) for each trial blast shall be made in accordance to a confidence level of 84%.

(4) After each trial blast a structural inspection of structures and tunnels shall be carried out to assess the effect of blasting induced vibration. The scope and extent of the structural inspection shall be agreed with the Authority Engineer. When no structural defects are reported the subsequent trial blasting may be increased to the next higher vibration target level, which shall not be exceeding the values specified in the Contract. Following completion of the Blasting Risk Assessment field works a Blasting Risk Assessment Report shall be required to be submitted to the Authority Engineer for Notice to Proceed.

The Report shall include the followings as minimum contents:

- Drilling and explosive loading details for each trial blast;
- Delay plan for each trial blast;
- Charge weight per blast hole and charge weight per delay for each trial blast;
- Details of vibration monitoring instruments and geophone locations and orientation for each trial blast;
- Details of instrumentation and settlement monitoring for each trial blast;

(5) Graphical record of Elapse Time against Particle Velocity and Acceleration for each of the three orthogonal geophone directions for each trial blast for each filtering frequency used. All records are to identify the following: date, time, monitor, location, filtering frequency, channel number, channel maximum, project and trial blast identification; full wave form of the vibration measured on structures and installations showing; PPV, predominate frequency, displacement and acceleration;

(6) Maximum resultant peak values calculated by vector summation of the three orthogonal components of velocity and amplitude for the monitoring point closest to each trial blast at each filtering frequency used. Results to include distance from blast and range of the dominant vibration frequency;

(7) Results of structural condition survey conducted following each trial blast, and results of vibration monitoring and all other structures and buildings;

(8) Results of all trial blasts plotted as a linear regression defining constants for that site condition and the 50%, 84% and 95% confidence levels. Results to include dominant vibration frequency recorded.

4.12.7 Blasting Trials

(1) The Contractor shall submit to the Authority Engineer for Notice to Proceed full details of the blasting trials at least 14 days before the trials are carried out. Blasting trials shall be carried out for each proposed blasting procedure to demonstrate that:

- The procedure is safe;
- The dust and noise created are within acceptable limits;
- The resulting maximum peak particle velocity and maximum allowable vibration amplitude at locations stated in the Contract, or instructed by the Authority Engineer , can be satisfactorily predicted, recorded and demonstrated to be within the prescribed limits, and shall not adversely affect the safety and stability of adjoining structures, installations and land, facilities & equipment; and
- The specified tolerances for the final blasted surfaces and formations can be achieved.

(2) Blasting trials shall be carried out in accordance with the blasting procedure submitted to the Authority Engineer. The location and size of blasting trials shall have a Notice to Proceed from the Authority Engineer. These trials should not normally be part of the permanent works.

(3) Blasting trials shall be completed at least 7 days before the related main blasting starts.

(4) Blasting trials for pre-splitting and other methods of controlled blasting shall be carried out to form a face similar to the permanent works design. The blasting trials shall be carried out on rock which has similar properties to production blast areas and which is at least 6m away from any permanent excavated surface or at a distance agreed by the Authority Engineer.

(5) The blasting trials shall be sufficient to demonstrate the effectiveness of the Contractor 's proposed methods of blasting in all of the different areas of the blasting works.

(6) The blasting trials shall be conducted by qualified personnel with a Notice to Proceed from the Authority Engineer.

(7) If in the opinion of the Authority Engineer any aspect of the proposed blasting procedure as demonstrated by the blasting trials is unsatisfactory, particulars or proposed changes to the procedure shall be submitted to the Authority Engineer for Notice to Proceed; further blasting trials shall be carried out until the procedure is demonstrated to the satisfaction of the Authority Engineer.

(8) The results of all trial blasts shall be interpreted using regression analysis method. Regression lines together with all blasting data showing the relationship of peak particle velocity against scaled distance shall be plotted on logarithmic scale to define the site vibration constants for the 50%, 84% and 95% confidence levels. All subsequent main production blasting results shall be produced on the same plot, and the plot modified and updated, as appropriate to allow for the additional information. Separate trials are required for different blasting types and areas.

(9) Blasting shall not proceed until the Authority Engineer has issued a Notice to Proceed to the proposed blasting procedure.

(10) If changes to the agreed blasting procedure are proposed further blasting trials shall be carried out to demonstrate proposed changes are acceptable.

4.12.8 Blasting Schedule

(1) The Contractor shall submit a weekly schedule to the Authority Engineer advising the proposed dates, times and locations of blasting, in advance of each week.

(2) The Contractor shall confirm his intention to proceed with each scheduled blast to the Authority Engineer not less than 18 hours, nor more than 24 hours in advance of the predetermined time. The confirmation shall show the location of and the intended time of each blast and the name of the licensed blaster and shift foreman responsible.

(3) The Contractor shall distribute written notification to all organization's on Site 24 hours prior to undertaking surface blasting. Any delay or postponement of any blasts shall be notified to all organization's immediately

4.12.9 Vibration Due to Blasting

(1) Arrangements for installing instruments and taking measurements both inside and outside the Site shall be made by the Contractor.

(2) Measurement of vibrations generated by blasting shall be taken at locations proposed by the Contractor in his Blasting Assessment Report, Building Damage Assessment Report and Monitoring Proposal or as instructed by the Authority Engineer at all times when blasting is carried out. Records of the vibrations shall be kept by the Contractor on the Site and a copy provided to the Authority Engineer within 24 hours of measurement.

(3) Vibrations due to blasting shall be measured in terms of Peak Particle Velocity (PPV) and Vibrational Amplitude. The peak values shall be taken as the maximum resultant calculated by vector summation of the three orthogonal components of velocity and amplitude respectively measured as instantaneously as the resolution of the recording instrument permits.

(4) Measurements shall be made with seismographs of a type with Notice to Proceed from the Authority Engineer. The accuracy of seismographs shall be checked before blasting are carried out and shall be calibrated at least once a year.

(5) No blasting works shall be permitted without vibration measurements being recorded with approved vibration monitoring equipment mounted on a geophone pad which is rigidly bonded to form an integral part of the structure. If a production blast results in vibration amplitudes or peak particle velocity in excess of the specified limits, the Authority Engineer shall be notified immediately.

(6) The Contractor shall immediately check the fixing of monitoring equipment to confirm the reading accuracy and inspect the integrity of affected structures to ensure no immediate danger to the public and to implement remedial measures if necessary. No

further blasting shall take place until measures to reduce the PPV and/or amplitude are adopted with a Notice to Proceed from the Authority Engineer.

(7) For structures in the proximity of blasting, the peak particle velocity shall be measured at the locations immediately adjacent to the structure nearest to the face being blasted or any other location where it is necessary to limit vibration.

(8) Vibration monitoring proposals shall be submitted to the Authority's Representative

(9) The measurement of peak particle velocity shall be obtained from instruments capable of measuring along three orthogonal axes, one of them shall be aligned parallel to the center line of the excavation and another shall be vertical. The Contractor has to provide supports for the measuring instrument if so, required by the manufacturer's instructions.

(10) The measurements of the particle velocities shall be the responsibility of the Contractor. Copies of the readings in an agreed form shall be supplied to the Authority's Representative.

(11) Prior to the commencement of blasting in any location, the Contractor shall demonstrate using test firings, or by other means, that neither the peak particle velocities given in the particular Standards and Specifications will be exceeded.

(12) The maximum allowable blasting vibrations shall be defined by the Contractor for every structure influenced with reference to the applicable Standards and Specifications for the relevant structure. The allowable blasting vibrations ·shall be approved by the Authority's Representative prior to any blasting operations.

4.12.10 Blasting Near Structures

(1) Blasting will not be permitted within 3m of the outside face of any existing underground structure. The Contractor shall propose alternative appropriate means of mechanical, pneumatic or hydraulic splitting for excavations at connections to existing structures for the Relevant Authorities' and Authority Engineer 's Notice to Proceed.

(2) The Contractor shall be responsible for avoiding personal injuries and damage to adjacent structures from fly rock by erecting barricades and/or the use of blast mats or other means acceptable to the Authority Engineer. Should any damage be caused by his operations this shall be made good without any additional payment.

(3) The unrestricted use of explosives will generally not be permitted in any part of the Works. The amount of explosives that may be detonated shall not result in a ground vibration sufficient to damage the nearest point of any part of the Permanent Works to the blasting Site.

(4) In each and every case where the Contractor wishes to blast within 15 m of a structure, he shall prepare a proposal for this blasting and submit it to the Authority Engineer for a 'Notice to Proceed, no blasting work of this nature may be carried out without the Notice to Proceed from the Authority Engineer.

(5) The Contractor shall prepare a photographic record of each structure within 100 m of any Works, whether on the surface or underground, prior to any blasting taking place

4.12.11 Limits of Peak Particle Velocity and Vibration Amplitude

(1) The vibrations at structures and installations due to blasting measured in terms of peak particle velocity and vibrational amplitude shall not exceed the values stated in Table 6.2

Table 6.2 Restriction on PPV and Vibration Amplitude

Description	**Max Allowable PPV (mm/sec)**	**Max Allowable Vibration**
Structures in "good" condition and Roads/Pavements/open areas	25	0.2

Structures in "fair" condition	12	0.15
Structures in "poor" condition and Heritage Structures/bridges and water supply structures	5	0.1
Fresh concrete: Less than 2 days old 2 to 8 days old more than 8 days old	5 25 50	0.1 0.2 0.2

(2) The Contractor shall submit calculations which demonstrate that the charge weights per delay period proposed at 84% Confidence Level do not exceed the vibration limitations stated in Table 6.2 to the Authority Engineer for Notice to Proceed. No blasting operations shall be carried out without Notice to Proceed from the Authority Engineer.

4.13 Explosives

a) The Contractor shall use explosives only in circumstances where it is safe to do so having due regard to the safety of persons, third-party property and the safety of the Works. Explosives shall not be used without the agreement of the Authority's Representative.

b) The Contractor shall obtain all necessary licenses and consents and shall provide secure storage facilities for all explosives and equipment in accordance with Indian or International Standards Code of practice for the safe use of explosives in the construction industry and the requirements of the local Authorities and the Authority's Representative.

c) Explosives shall be handled and used only by the Contractor's duly authorized personnel. The names and qualifications of such personnel shall be submitted to the Authority's Representative in writing in advance of any possible use of explosives.

d) At an early stage, in advance of the proposed use of explosives, the Contractor shall notify the Authority's Representative, third parties, statutory authorities and services which have an interest in or are likely to be affected by blasting operations, of the general nature of the operation. The Contractor shall subsequently give a minimum of 14 days' notice to the Authority's Representative and others described above of the proposed use of explosives. With this notification the Contractor shall submit to the Authority's Representative a-detailed method statement on all aspects of the proposed 'use of explosives, including the treatment of misfires.

e) The Contractor shall comply with the following documents in respect of the use of explosives:

- Indian Explosives Act 1884
- Indian Explosive Rules 2008 and further amendment in Jan.2009
- The Manufacture and Storage of Explosives Regulations 2005
- BS 5607:1998 Code of practice for the safe use of explosives in the construction industry
- Control of Explosives Regulations 1991
- Carriage of Explosives by Road. Road Traffic (Carriage of Explosives) Regulations 1996
- PD CLC/TR 50426:2004 Assessment of inadvertent initiation of bridge wire electro-explosive devices by radio- frequency radiation. Guide Quarries (Explosives) Regulations 1988, as far as it is relevant to tunnel works

4.14 Geological Mapping

a) Geological mapping shall be performed by qualified geologists to provide a documentation of rock and rock mass condition encountered during excavation. -Additionally, all exposed rock surfaces of the open and underground excavations shall be washed down

for inspection and geological mapping. Exposed rock surfaces at the required excavation pay lines shall be mapped after preparation but before shotcrete application. Tunnel and other underground faces shall be mapped just before the start of drilling. The Contractor shall allow in his construction procedure and schedule for the geological mapping Qf each tunnel face not less than 30 minutes.

b) The geological mapping shall include but not limited to the following information:

• excavation face

• tunnel meter

• geological unit

• intact rock:

• rock type and lithology description

• weathering and alteration degree

• uniaxial and unconfined compressive strength (from point load tests)

• rock mass:

o -jointing degree

o -geometry, orientation (strike and sip) and properties of discontinuities

o - face condition (homogeneous or heterogeneous)

o - water inflow

o -over breaks (separated in geological and non-geological)

o - ground response

o - suspected pervious zone

• the GSI value and the corresponding excavation class

• groundwater appearance

g) The Contractor shall provide lights, ladders, platforms and free access and shall assist the Authority's Representative to carry out inspection and geological mapping.

h) In case of sudden and unexpected changes of the geological conditions, the same shall be informed immediately to the Authority Engineer.

4.15 Excavation Cross Section Check

a) Tunnels will be constructed to the center lines as defined herein and subsequently agreed on site. Average deviation of the tunnel centerline from the design centerline, along a 100 m length of any tunnel section, shall not exceed 30 mm. If deviations in tunnels excavated exceed the specified tolerance, the Contractor shall be required to adapt his working methods so that the specified tolerances are achieved.

b) Immediately after excavation and before support installation the cross section of the actual round must be checked to avoid unexcavated ground reaching into the excavation area as per excavation and support category. The check must be done with proper instrumentation, either with free positioned theodolite or with temporarily installed monitoring device for profile check. When all ground material inside the excavation area is removed the support installation shall start earliest.

c) In case of partial excavation, the similar procedure shall be executed for each partial excavation.

4.16 Excavation Material Disposal

a) The disposal of excavation material shall be in accordance with specified compliance. Excavation material suitable to be utilized in the works shall be stockpiled separately from materials to be disposed. The use of excavation material in the works shall agree with the Authority and IE.

b) Suitable materials shall, wherever possible, be transported directly from the required excavation to the various designated final locations.

c) Excavated materials, not suitable for or more than the construction requirements, shall be disposed of in spoil areas designated by the Local Authorities or the Authority's Representative. Unless otherwise provided for, spoil areas shall be built up in layers, with a maximum layer thickness of 0.5 m, and evenly compacted by the traffic of the construction equipment, aimed at minimizing future differential settlement. Final sloping and shaping of surfaces shall be as directed by IE. Other details of the work such as stabilization and drainage measures shall be as directed by IE.

d) All activity by the Contractor at spoils areas shall be confined to the limits designated by the Local Authorities or the Authority's Representative. The limits shall be clearly marked and, where directed barricaded to prevent traffic in areas outside the limits.

4.17 Urban Road Tunnel – Construction Phase: Comprehensive Disaster Management and Security Plan (CDMSP)

The construction of an urban road tunnel involves numerous inherent risks, including the possibility of structural collapse, underground fire, toxic gas release, flooding, and machinery accidents. To address such risks proactively, a Comprehensive Disaster Management and Security Plan (CDMSP) is mandated under Schedule D of the Contract Agreement. This document outlines a robust framework that the Contractor must adopt, focusing specifically on the challenges encountered during the construction phase of the tunnel. The plan emphasizes preparedness, prevention, mitigation, response, recovery, and coordination with statutory authorities, ensuring that construction proceeds with minimal risks to life, property, and environment.

1. Objectives of the CDMSP (Construction Phase)

The CDMSP aims to create a safe and responsive environment for all stakeholders involved in tunnel construction. The specific objectives include:

a) Preparedness: Establish structured procedures and training mechanisms to ensure that all personnel can respond swiftly to any emergency.

b) Risk Minimization: Reduce the likelihood and potential consequences of disaster scenarios associated with underground construction.

c) Rapid Response: Ensure the immediate mobilization of trained personnel and resources to manage incidents effectively.

d) Protection of Life and Infrastructure: Safeguard human life and maintain the integrity of ongoing tunnel works and associated temporary structures.

2. Key Components of the Disaster Management Plan

2.1 Risk Identification and Assessment

Prior to commencing tunneling activities, the Contractor shall conduct a detailed risk and hazard assessment based on:

- Geological and geotechnical studies to identify fault zones, high groundwater levels, or unstable rock formations.
- Identification of potential human-induced hazards including electrical faults, equipment malfunction, fire, and human error.

A dynamic Hazard Risk Register shall be maintained and updated as new risks are identified during construction progress.

2.2 Disaster Prevention and Mitigation Measures

Prevention and mitigation strategies must include:

- Installation of dewatering systems, sump pits, and submersible pumps to prevent flooding during excavation.
- Use of temporary ground support systems such as rock bolts, steel ribs, and shotcrete in weak strata.

- Deployment of multi-point extensometers, strain gauges, and tunnel convergence monitors to detect early warning signs.
- Provision of gas detection systems (methane, CO, H2S) with alarms and data logging.
- Redundant power supply systems to support ventilation, lighting, and communication during power outages.

2.3 Emergency Preparedness

- Dedicated Safety Officers will be present on each shift and shall have authority to halt operations in case of unsafe conditions.
- Safety and fire-fighting equipment including CO2 and dry chemical extinguishers shall be installed at intervals of 100 meters.
- Refuge chambers, fitted with compressed air cylinders and communication devices, shall be located at every 500 m interval.
- Routine mock drills and table-top exercises shall be conducted in collaboration with external emergency agencies.

2.4 Incident Response and Management

- A centrally located Emergency Control Unit (ECU) will coordinate all on-site emergency actions.
- Incident types shall be categorized (e.g., minor, major, catastrophic) and protocols developed for each, including chain-of-command and escalation levels.
- Emergency communication will be maintained through wired intercoms, mobile radios, satellite phones, and public address systems.
- Incident response kits shall include oxygen masks, stretchers, thermal blankets, and cutting/rescue tools.

2.5 Evacuation and Rescue Operations

- Designated evacuation routes with directional signage shall be created from working faces to surface escape points.
- Manual ladders and staircases shall be installed at intermediate shaft levels.
- Rescue teams trained in confined space recovery, first aid, and smoke diving shall be stationed at site.
- Emergency vehicles with stretcher arrangements must be stationed at tunnel portals for immediate transport to medical facilities.

2.6 Recovery and Rehabilitation

- After any major incident, a detailed incident analysis report will be prepared.
- Stability checks and certification of the affected tunnel section must be completed prior to resumption of works.
- Emotional counselling and medical rehabilitation support will be provided to injured workers.
- Documentation and learnings from incidents shall be incorporated into revised operating procedures and safety checklists.

3. Construction Phase Security Measures

In urban environments, construction sites are vulnerable to unauthorized access and vandalism. Security protocols must include:

- Perimeter fencing with barbed wire and illumination around all shaft locations and camps.
- Controlled entry through biometric or RFID-based access systems.

- CCTV surveillance with 24x7 recording and real-time monitoring.
- Appointment of trained security personnel on rotational duty.
- Incident coordination protocol with local law enforcement for intrusions, thefts, or sabotage attempts.

4. Institutional Coordination and Monitoring

- Formation of a site-level Emergency Response Coordination Committee (ERCC) chaired by the Project Director.
- Regular liaison with District Disaster Management Authority (DDMA), local police, fire department, and hospitals.
- Notification and communication systems integrated with a central project dashboard.
- Use of IoT-based wearable devices to monitor worker presence and health parameters inside the tunnel.

5. Codal Provisions and Technical Guidelines

The CDMSP shall strictly conform to the following standards:

Standard/Guideline	Description
IRC SP:91-2019	Indian Guidelines for Road Tunnels
NFPA 502	Fire Protection Standards for Road Tunnels
IS 475:2021	Indian Seismic Safety Standard
ISO 22320:2018	Global Emergency Management Protocols
NBC 2016	Indian Building Code on Fire Safety
PIARC Reports	Global Best Practices in Tunnel Safety
DGMS Circulars	Safety in Underground Construction

6. Documentation, Approval, and Review

- The draft CDMSP must be submitted for approval to the Authority Engineer (IE) within 60 days of achieving Financial Closure.
- The plan shall be reviewed and updated every 6 months or following any significant incident or safety audit observation.
- A final version of the plan shall be appended to the project's Construction Environmental and Social Management Plan (CESMP).

Section 5

Electromechanical Works

5. General

5.1.1 Operation Philosophy

a) The Operations Control Centre for the tunnel is located at the Portal Ends of the Tunnel. The operation of the tunnel equipment shall be done in such a way that it operates fully automatically without intervention from the Control Centre. The Control Centre shall supervise the automatic operation and optimize the operation manually.

b) The work for all automatic processes shall be split on Programmable Logic Controls (PLC) and distributed I/O units for communication with connected PLCs. The local data transmission between the single equipment / appliances (like PLCs, distributed I/O units, etc.) shall be realized by use of an optical fiber cable "tunnel-ring". To this tunnel-ring every appliance for data transmission at the electrical rooms as well as tunnel Niches.

c) This modular architecture guarantees that the function of the whole system cannot be lost caused by a single defect unit and the supervision and control of the tunnel can be still done in an adequate way.

d) If an error occurs in one PLC or I/O unit, the operation of all other PLCs and I/O units must not be influenced by the localized fault.

e) If an error (wherever) in a communication service appears while the communication service cannot be made in a redundant way (for example if the optical fiber cables of the tunnel-ring are damaged due to construction works), the various controls on both sides shall continue their operation as standalone controls automatically.

5.1.2 General Information

a) These specifications shall be regarded as general specifications describing the required material, equipment, labour, etc. for the required installation such as Lighting, Ventilation, firefighting etc.

b) The Contractor shall check the accordance of the offered material, equipment, etc. with the requirements and standards presented in these specifications.

c) The Contractor shall make the shop drawings according to the material offered, equipment, labour, etc. where the actual values such as cable diameters, voltage drop, power, etc. shall be shown with the used material.

d) Therefore, the Contractor shall send detailed information of the material used (such as catalogues, instruction manuals, data sheets, etc.) to the Independent Authority Engineer for his approval.

e) All systems and products, which were offered by the tenderer, must be available in India.

5.1.3 Scope of works

a) The scope of tunnel electromechanical works include:

- 33kV System
- 11kV system
- 433/250 V – 50 Hz Power Supply
- Emergency Power Supply
- Earthing and Potential Equalization
- Tunnel Lighting
- Tunnel Fittings
- Fire Detection

- Telecontrol System / SCADA

5.1.4 Quality of Material and Workmanship

a) All goods, materials, plants and equipment incorporated in the permanent contract works shall be of approved reliability, well established design, of best quality of their respective kinds and shall comply with all relevant standards as given in this specification.

b) All plant and equipment shall be properly finished for the ambient conditions and circumstances of use.

c) The ambient temperature at site varies between 15 °C and 35 °C, and relative humidity varies between 55 % and 85%.

d) All equipment shall be with the approval of the Authority Engineer ; the Contractor shall be responsible for any delays caused due to submission of unacceptable materials in connection with such approvals.

e) Wherever different materials are used, attention shall be paid to the electrochemical reactions (electrolytic corrosion) of these different materials (e.g. copper / steel, aluminum /steel and so on). However, suitable steps shall prevent any of these electrochemical reactions.

f) "Stainless steel " shall be 316 S 11 or 320 S 31 according BS.

g) Galvanized steel shall be used only when specified. "Galvanized steel" is always hot dip galvanized steel with zinc cover according to BS EN ISO 1461.

5.1.5 Paint

a) The colour of the paint shall be as per the decision of the Authority Engineer using standard RAL-colors.

b) Primary treatment of the metal: The surface of the metal shall be treated according to BS EN ISO 12944-4 (for steel the rust shall be removed).

c) Painting layer: 2 layers of primer, each of 40-micron thickness 2 layers of paint, each of about 60-micron thickness. The total thickness of the layers shall be about 200 microns.

d) Quality of paint: The paint shall be two component types with high latticed polymerization and low capillary development, adequate for tunnel atmosphere, resistant against salt water, high resistant against ultraviolet light, resistant against oil, acid and leach, insensitive against fat and free from heavy metal.

e) The temperature demand is from 0 °C to 120 °C.

5.1.6 PORTAL AND SERVICE BUILDINGS

Design, supply and install a complete lighting, power and communications system for the Portal buildings for both the north and south portals and facilities area near South and North portals.

General

Carry out Testing and Commissioning of all electrical systems and components.

Carry out training of personnel.

Submission of Documentation.

Provision of As-Built documentation and manuals. Provision for sealing all penetrations.

Provision. of spare parts and associated storage cabinets. Provision of tools and associated storage cabinets. Carry out maintenance during the warranty period.

The Contractor shall be responsible for the following:

Co-ordination with other trades and supplying details to other trades to enable them to make the necessary provisions for the installation.

Coordination with other tunnel services Contractor and supplying details to those Contractor to enable them to make necessary provisions for the installation.

Provide and undertake all necessary modification, provisions and adjustments necessary to achieve the design intent as indicated on· the drawings and the specifications.

Liaise and coordinate with all authorities having jurisdiction.

Liaise and coordinate with Administration Building Services Contractor.

Work not to be executed under this section of the contract, by the E&M Contractor (not under this scope). Note specific clarifications and exceptions

The following work will be carried out by other sub Contractor:

Major penetrations and trimming etc necessary to accommodate the works. Masonry risers/ shafts for exhaust /supply air.

Niche required for equipment installation.

Provision of floors drains and sump pits as required in plant rooms. Installation of rock bolts.

Plinths for major equipment as required

5.1.7 Lightning Protection

a) The Contractor shall take all the necessary and adequate precautions against influences and damage, which may occur due to lightning strikes in the region on all of the electrical equipment.

b) All low voltage and communication metallic cables entering the Service Buildings, electrical rooms or the Control Centre shall be protected against over voltages with special surge arrestor banks for control cables.

c) The Contractor shall provide all measures of lighting protection and shall obtain the approval of the engineer and the employer.

5.1.8 Ground and Bonding

a) All exposed metal work and metal which is not current-carrying part of the electrical circuitry, including equipment enclosures, panels and supports shall be bonded together and to ground. Substantial non-ferrous ground lugs or studs shall be fitted for bonding cable shields or other adjacent equipment.

b) Where sections of distribution cabinets / panels shall be placed together to form a composite unit, a bonding strip shall be provided through the intermediate sections to provide a complete bonding between all sections.

c) The connections of grounding and bonding shall be stud- or clamp- type.

d) These requirements shall apply irrespective of the operating voltage and purpose of the equipment.

e) All required suppression chokes / filters shall be included and shall be capable of withstanding faulty conditions. All cable shields shall be bonded together and shall be connected to the ground electrode. Particular attention shall be paid to the correct bonding and grounding of single core cable shields.

f) The Earthing bus bar for Electromechanical Installations shall be permanently connected to the main Earthing bus bar.

5.1.9 Submittals

a) Working detail drawings and descriptions of materials and equipment shall be submitted and shall include sizes, details and arrangements of numbers, method of assembly and testing, lists of materials and such other data as required permitting to the

engineer to check the adequacy of the proposed installation.

5.1.10 Standards and Regulations

a) Standards and regulations of the following organizations shall be applied for the completion of the works wherever applicable as applicable at the time of execution of works.

b) Indian Standards

Standard	Title
IS 13118	Specification for High-Voltage Alternating-Current Circuit-Breakers
IS 13118	Specification for High-Voltage Alternating-Current Circuit-Breakers
IS/IEC 60947-3	Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IS/IEC 60947-3	Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IS 3427-1997	A.C. Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and up to and Including 52 kV
IS 5082	Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes
IS 1897	Copper strip for electrical purposes - Specification
IS 8084	Interconnecting bus bars for ac voltage above 1 kV up to and including 36 kV
IS 5578	Guide for marking of insulated conductors
IS 11353	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals
IS 2705 PART1	Current transformers: Part 1 General requirements
IS 2705 PART2	Current transformers: Part 2 Measuring current transformers
IS 2705 PART3	Current Transformers : Part 3 Protective current Transformers
IS 2705 PART4	Current transformers: Part 4 Protective current transformers for special purpose applications
IS 3156 PART 1	Voltage transformers: Part 1 General requirements
IS 3156 PART 2	Voltage transformers: Part 2 Measuring voltage transformers
IS 3156 PART 3	Voltage Transformers : Part 3 Protective voltage Transformers
IS 3156 PART 4	Voltage Transformers : Part 4 Capacitor voltage Transformers
IS 1248 PART 1	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part: 1 General Requirements
IS 1248 PART 2	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 2: Ammeters and Voltmeters
IS 1248 PART 3	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 3: Wattmeter's and Varmeter's
IS 1248 PART 4	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories - Part 4: Frequency Meters
IS 1248 PART 5	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories - Part 5: Phase Meters, Power Factor Meters and Synchroscopes
IS 1248 PART 6	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 6: Ohmmeters (Impedance Meters) and Conductance Meters
IS 1248 PART 7	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 7: Multi-Function Instruments
IS 1248 PART 8	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories - Part 8: Accessories
IS 1248 PART 9	Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories - Part 9: Test Methods
IS 1651-1991	Stationary cells and batteries, lead-acid type (with tubular positive plates)

Standard	Title
IS 13010-	ac Watt hour Meters, Class 0.5, 1 and 2 - Specification
IS 13779	ac Static Watt hour Meters, Class 1 and 2 - Specification
IS 8530	Maximum demand indicators (class 1)
IS 14415	Volt-Ampere hour meters for restricted power factor range - specification [superseding IS:722 (Part 5):1980
IS 14372	Volt-ampere hour meters for full power factor range [superseding IS:722(Part 7/Sections 1, 2 and 3)-1987]
IS 1554 PART 1	PVC insulated (heavy duty) electric cables: Part 1 For working voltages up to and including 1 100 V
IS 1885: Part 32	Electro technical Vocabulary: Part 32 Electric cables
IS 8130	Conductors for insulated electric cables and flexible cords
IS 8130	Conductors for insulated electric cables and flexible cords
IS 2961	Chrome retains finished upper leather
IS 5819	Recommended Short-circuit Ratings of High Voltage PVC Cables
IS 5831	PVC insulation and sheath of electric cables
IS 694	PVC Insulated cables for working voltages up to and including 1100 V
IS 7098 PART 1	Cross linked polyethylene insulated PVC sheathed cables: Part 1 For working voltage up to and including 1 100 V
IS 7098 PART 2	Cross linked polyethylene insulated PVC sheathed cables: Part 2 For working voltages from 3.3 kV up to and including 33 kV
IS/IEC 60947-1	Low-voltage switchgear and control gear: Part 1 General rules
IS/IEC 60947-2	Low-Voltage Switchgear and Control gear - Part 2 : Circuit Breakers
IS/IEC 60898-	Electrical accessories - Circuit-breakers for over current protection for household and similar installations: Part 1 Circuit-breakers for ac operation
IS 8828	
IS 2062	Hot Rolled low, medium and high tensile structural steel
IS 1180 PART 1	Outdoor type three-phase distribution transformers up to and including 100 kVA 11 kV: Part 1 Non-sealed type
IS 1180 PART 2	Outdoor type three-phase distribution transformers up to and including 100 kVA 11 kV: Part 2 Sealed type
IS 1370	Transmission belting - Friction surface rubber belting - Specification
IS 13703 PART 1	LV Fuses for voltages not exceeding 1000 V ac or 1500 V dc: Part 1 General requirements
IS 13703 PART 4	Specification for Low-Voltage Fuses for Voltages not Exceeding 1000 V AC or 1500 V DC - Part 4: Supplementary Requirements for Fuse Links for the Protection of Semiconductor Devices
IS/IEC 60947-1	Low-voltage switchgear and control gear: Part 1 General rules
IS/IEC 60947-3	Low voltage switchgear and control gear: Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units
IS 13947 PART 4/SEC 1	Specification for Low-Voltage Switchgear and Control gear - Part 4: Contractor and Motor-Starters - Section 1: Electromechanical Contactors and Motor Starters
IS 2086	Carriers and bases used in rewirable type electric fuses for voltages up to 650V
IS 10027	Composite Units of Air-break Switches and Rewirable Type Fuses for Voltages Not Exceeding 650 V a.c. - Specification
IS 12640 PART 1	Residual Current Operated Circuit - Breakers for Household and Similar Uses: Part 1 Circuit-Breakers Without Integral Over Current Protection (RCCBs)
IS 12640 PART 2	Residual Current Operated Circuit - Breaking for Household and Similar Uses - Part 2 Circuit - Breakers with Integral Over current Protection (RCVOs)
IS 2075	Ready Mixed Paint, Stoving, Red Oxide Zinc Chrome, Priming - Specification
IS 8623 PART	Specification for Low-Voltage Switchgear and Control gear Assemblies - Part 1:

Standard	Title
1	Requirements for Type-Tested and Partially Type-Tested Assemblies
IS 8623 PART 2	Specification for Low-voltage Switchgear and Control gear Assemblies - Part 2: Particular Requirements for Busbar Trunking Systems (Bus way)
IS 8623 PART 3	Specification for Low-Voltage Switchgear and Control gear Assemblies - Part 3: Particular Requirements for Equipment Where Unskilled Persons have Access for Their Use
IS 9920 PART 1	High Voltage Switches - Part 1: Switches for Rated Voltages Above 1 kV and Less Than 52 Kv
IS 9920 PART 3	Specification for Alternating Current Switches for Voltages Above 1 000 V - Part III: Design and Construction
IS 9920 PART 4	Specification for Alternating Current Switches for Voltages Above 1000 V - Part 4: Type Tests and Routine Tests
IS 13947 PART 5/SEC 1	Low-Voltage Switchgear and Control gear - Specification - Part 5: Control Circuit Devices and Switching Elements - Section 1 : Electromechanical Control Circuit Devices
IS 2675	Enclosed distribution fuse boards and cutouts for voltages not exceeding 1000 V Ac and 1200 V Dc
IS 8084	Interconnecting bus bars for ac voltage above 1 kV up to and including 36 kV
IS 5561	Specification for Electric Power Connectors
IS 9921 PART 1	Specification for Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1 000 V - Part I : General and Definitions
IS 9921 PART 2	Alternating current disconnectors (isolators) and earthing switches for voltages above 1000 V: Part 2 Rating
IS 9921 PART 3	Specification for Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1000 V - Part III: Design and Construction
IS 9921 PART 4	Specification for Alternating Current Disconnectors (isolators) and Earthing Switches for Voltages Above 1000 V - Part 4: Type Tests and Routine Tests
IS 9921 PART 5	Specification for Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages Above 1 000 V - Part 5: Information to be Given with Tenders, Enquiries and Orders
IS 15086: Part 1	Surge Arresters - Part 1: Non-Linear Resistor Type Gapped Surge Arresters for a.c. Systems
IS 3070 PART 3	Lightning Arresters for Alternating Current Systems - Specification - Part 3 : Metal Oxide Lightning Arresters Without Gaps
IS 9385 PART 1	High voltage fuses: Part 1 Current limiting fuses
IS 9385 PART 2	High voltage fuses: Part 2 Expulsion and similar fuses
IS 9385 PART 3	High voltage fuses: Part 3 Application guide for high voltage fuses
IS 9385 PART 3	High voltage fuses: Part 4 Determination of short-circuit power factor for testing of high voltage fuses
IS 13118	Specification for High-Voltage Alternating-Current Circuit-Breakers
IS 12729	Common Specification for High-Voltage Switchgear and Control gear Standards
IS 8187	D-type fuses
IS 7567	Automatic circuit reclosers
IS/IEC 60947-1	Low-voltage switchgear and control gear: Part 1 General rules
IS/IEC 60947-2	Low-Voltage Switchgear and Control gear - Part 2 : Circuit Breakers
IS 3427	A.C. Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IS 3156 PART 1	Voltage transformers: Part 1 General requirements
IS 3156 PART	Voltage transformers: Part 2 Measuring voltage transformers

Standard	Title
2	
IS 6046	Specification for Gypsum for Agricultural Use
IS 13118	Specification for High-Voltage Alternating-Current Circuit-Breakers

c) International Standards

- British Standards
- EN European Standards
- IEC International Electrotechnical Commission
- IEE Institution of Electrical Engineers
- CISPR International Special Committee on Radio Interference CENELEC Comité Européan de Normalisation Elektrotechnique
- ITU-R Comité Consultatif International des Radio communications ITU-T Comité Consultatif International Télégraphique et Téléphonique

d) Unless another standard is specifically mentioned in these specifications, all materials used and provided under the contract and all equipment, calculations and tests shall be in accordance with the standards mentioned before or in accordance with such authorities' standards appropriate to the country of manufacture as in the opinion of the engineer to ensure an equivalent or higher quality.

e) If the Contractor offers materials, equipment, calculations, or tests which conform to standards other than the standards mentioned before, full details of differences between the proposed standard and the above-mentioned standards, as far as they affect the design or performance of the equipment, shall be submitted.

f) The Work and all plant, equipment and materials forming part of these specifications shall comply (in all respects) with the rules and regulations of the supply authority and any other authorities having jurisdiction over any part of the work and on the method of performing such work.

5.1.11 Tests

a) Tests shall be generally divided into three sections:

I. Factory Acceptance Tests (F.A.T) shall be carried out before the delivery of the plant / equipment

II. Site Acceptance Tests (S.A.T.) shall be carried out after the plant / equipment is delivered and installed on site

III. Tests on completion

b) The Contractor shall submit catalogues of all equipment as well as a list of the tests proposed for all equipment. A general overview of each of the proposed tests shall be included in these documents. Any of these pre-given descriptions or documents shall not limit in any way the Contractor's obligations to complete every test as specified and necessary to demonstrate the satisfactory performance of the system.

c) The schedules of each test, as well as the test procedures itself shall be prepared, based on the detailed description of the test previously submitted in accordance with the final system proposal and as approved by the engineer. No deviations are allowed without prior approval by the engineer.

d) The Contractor shall submit for the engineer's approval all detailed test procedures and final schedules for the tests at least eight weeks prior to the scheduled commencement of the Factory Acceptance Tests.

e) Prior to this time the draft procedures shall be submitted and agreed by the engineer. The Contractor shall indicate when these draft procedures shall be submitted.

f) In case of a defect being detected during one of the tests, the nature of the defect shall be explained in detail to the engineer. Based upon this information, the engineer shall decide whether the defect is a minor fault or whether it must be corrected before testing can continue.

g) Minor faults are defects, which are found during testing, and which do not adversely affect the operation of the system in a broad sense and thus don't need be rectified / corrected before a test can be continued and successfully completed. If the defect is not a minor fault, the engineer shall decide which section of the test (or tests) must be repeated. The engineer shall have the right to require all tests to be repeated, if he decides that the defect has wider consequences.

h) All costs involved in any retesting shall be at the expense of the Contractor including supervisory and employer's costs.

i) The engineer or his appointed representative shall always have unrestricted access to the Contractor's and supplier's premises for purposes of inspection and tests and the Contractor shall specify this requirement when placing all orders.

j) All relevant expenses (i.e. transportation, accommodation) of those who supervise the subject's tests and inspections (engineer and at least one additional representative of the employer) shall be at the expense of the Contractor.

k) Factory Acceptance Tests (F.A.T) - Factory Acceptance Tests are divided into three parts:

- Environmental tests
- Technical tests
- System tests

i. Factory acceptance tests shall be conducted under the supervision of the employer and the engineer. The Contractor shall group tests to minimize travel expenses if the engineer and / or the employer attends the tests.

ii. After completion of the tests the results, certified by the employer or the engineer's representative, if present in any of such tests, shall be forwarded to the engineer. When the engineer has received the results and states that the plant / equipment has passed the tests, he will write to the Contractor to inform him, and the Contractor then may ship the plant.

iii. If the engineer deems that the plant / equipment is not in accordance with the specifications, he may reject the plant / equipment and shall inform the Contractor of the reasons in a writing within a reasonable time limit.

iv. The engineer shall also inform the Contractor in writing if any minor faults are detected and which of these minor faults shall be corrected before shipment.

l) Site Acceptance Tests (S.A.T)

i. If each section of plant is installed, commissioning tests for each section shall be carried out on site.

ii. At least six weeks in advance of any particular site testing, the Contractor shall submit details of tests and details for the test equipment he proposes to use for that testing to the engineer for his approval.

iii. As installation proceeds, the insulation resistance of cables shall be checked and recorded. The identification of the cores shall be confirmed from end to end of each cable end, in the case of communication-, alarm- and control-cabling, from end to end of each circuit. Tests on cables shall be completed and accepted by the engineer before the testing of the associated equipment starts.

iv. All tests for statutory requirements and insurances including arrangements for such tests, inspections by authorized bodies, persons or insurers, as necessary and the

provision of certificates in the prescribed and approved forms necessary to enable plant and equipment to be put into service, shall be made by the Contractor.

v. On-site commissioning tests being subject of acceptance by the engineer shall include:

a. All equipment, cabling, distribution etc. is electrically and mechanically safe

b. All interlocks, isolators and door and cover securing mechanisms shall be properly fitted and adjusted.

c. All the exposed metal work is properly bonded and grounded and that all connections and points required to be grounded for a safe and satisfactory operation shall be properly grounded in accordance with the manufacturer's requirements.

d. All cables, cores and terminations shall be secure, properly fitted and correctly identified and coloured.

e. All phases, polarities, neutral and common connections shall be correctly switched / connected as required, so that the power is correctly available at all points and that the voltage and frequency at all equipment is correct and in accordance with the requirements for correct work

f. All supplies shall be properly fused or otherwise protected, to give successfully discrimination and safe disconnection under fault conditions.

g. All contacts shall be properly aligned / adjusted and not subject to excessive wear or corrosion.

h. Batteries shall be correctly installed, connected and fitted and checked that the battery chargers are working correctly.

i. The insulation-resistance of all cabling and equipment shall not be less than specified.

j. All instruments and meters shall be energized with correct polarity and working properly.

k. All fault indications and alarms shall be working correctly.

l. In addition to all operational tests, required for a successful hand-over, the operation of all interlocks, sequences and protections which are not utilized in normal operations shall be subject of acceptance by the engineer.

vi. The on-site commissioning tests shall be conducted under the supervision of the engineer.

vii. The final acceptance tests shall begin after all on-site commissioning tests have been successfully completed and all defects detected during those tests have been rectified / corrected, which is accepted by the engineer. The tests shall include full operation tests on the works as a whole and selected technical tests on some or all of the equipment.

viii. On completion of the site acceptance tests, the Contractor shall forward the test results certified by him to the engineer. When the engineer has received the results and deems that the plant has successfully passed the tests, he will write to the Contractor to that effect.

ix. During the site acceptance tests the engineer shall inform the Contractor of minor faults detected and which of these minor faults shall be corrected before the beginning of the tests on completion.

5.1.12 Tests on Completion

1) The Contractor shall notify the engineer when the tests on completion shall be made. All minor faults detected during the previous tests shall be corrected to the satisfaction of the engineer prior to the start of the tests on completion.

2) The system shall be fully operational and shall operate successfully. During these periods, the whole system shall be available to the Engineer.

3) Fire Test

a) To get evidence of fully functional and right working tunnel ventilation in case of fire, in the tunnel a hot fire test shall be made.

b) This fire test shall be made during the testing time of the Contractor in cooperation with the fire brigade, the employer, and the designer of the tunnel ventilation system.

c) The place(s) of the fire test shall be in agreement with the fire brigade and the employer (the test shall be made at the most unfavorable place for the tunnel ventilation).

d) The aim of the test is to:

i Prove the functionality of tunnel ventilation in case of fire

ii Discover the exhaust capacity of the ventilation system

iii Prove the different driving-programs of the ventilation system in case of fire and adapting / changing these programs, if the fire test results new cognitions.

e) This data shall be acquired:

i Air velocity in the tunnel (value and direction): before and during the test

ii Controlling the tunnel ventilation

iii The rising temperature along the tunnel (in the area of the test)

iv Video recording with the CCTV cameras in the tunnel

v Recording of all alarms and messages during the test

f) Additionally, these data shall be acquired: (therefor necessary equipment shall be included in this item)

i Detection of the spread of the fire and of the layering of the fume with two cameras (in each direction next to the testing place with one camera)

ii Air velocity In each direction, approx. 50 m next to the testing place, the air velocity shall be measured with 3 anemometers; furthermore the air velocity also shall be recorded by a data logger as function over time.

g) The progress, as well as all results of the fire test shall be documented. The protocol shall be handed over to the employer. The video recordings shall be handed over in mpeg-format.

5.1.13 Trial Operation

1) The trial operation shall occur with full responsibility of the Contractor. The trial operation shall take place after finishing the tests on completion. For starting the trial operation, it is required, that all tests on completion are finished positive for the entire installation and shall occur within 21 days.

2) The trial operation shall show the evidence of a fully functional operation of the tunnel and that security is given during operation. Therefore, the trial operation shall occur without significant malfunctions.

3) The Contractor shall test different operation cases during the trial operation (e.g. loss of different equipment etc.).

4) The Contractor shall make organizational measurements during the trial operation, so that malfunctions can be rectified as soon as possibly (within max. 2 days).

5) The results of the different tests during trial operation shall be shown in a protocol. This protocol shall be signed by the Contractor and the employer. If the protocol shows that all contractual conditions are kept, the tunnel shall be taken over by the employer.

5.1.14 Trial Operation

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5.1.15 Staff Training

1) During the contract period, the Contractor shall provide training manuals, as well as on-site training and training courses to ensure that the employer's staff associated with this project may acquire full knowledge and appreciation / understanding of all aspects of the design, day-to-day operation, breakdown and routine maintenance and fault diagnosis of the power supply, the surveillance and control equipment as well as the belonging hard- and software.

2) The Contractor shall train the employer’s personnel about all equipment in theoretical and practical ways. Also the maintenance shall be trained.

3) The employer will nominate members of his staff who are attending the training courses.

4) The Contractor shall nominate qualified instructors. It shall be essential that prior approval of the engineer is obtained for the instructor and the instructor's qualifications in each case.

5) The Contractor shall provide all relevant and necessary facilities which are needed for complete and effective staff training (such as video, TV, slide- and film projectors and others).

6) The Contractor shall provide all facilities including accommodation, transport and catering for all trainees.

7) Within two months after the signing of the contract, the Contractor shall submit a detailed syllabus for the training courses for approval by the Engineer.

5.1.16 Documentation

1) There will be the following stages for documentation

- Project for execution
- As-built documentation
- Manuals for operation and maintenance

2) Final system manuals and instructions for operation and maintenance respectively compound project of executed works.

5.1.17 Project for Execution

(a) The purpose for the final system proposal shall be to form a complete basis on which detailed work can proceed. Without the specific written approval by the engineer, the Contractor shall not place any equipment on order or begin with the manufacture of any plant/equipment until the engineer has approved the final system proposal. The final

system proposal shall be submitted for the approval of the Engineer.

(b) This final system proposal phase shall include specifications of:

- All low-voltage power supply
- all emergency power supplies
- All earthing and potential equalization
- All the lighting
- All tunnel fittings
- All ventilation equipment
- All fire detection systems
- All SCADA system
- Acceptance testing
- Documentation of organization
- Data and communication equipment

(c) Software Final System Proposal

(1) The final software system proposal shall contain flow charts and descriptions of the whole software structure explaining the operation and interaction of the various programs. All operation functions and interfaces to be provided in each central and local system(s) shall be specified. The interfaces between single programs and data structures shall be designed. Critical timings shall be evaluated and displayed.

(2) The document shall concentrate on producing and describing adequate overall system design with unified systems of data modification, etc.

(3) If standard programs are used, detailed documentation for each program shall be provided. This shall include a functional description of the program(s), with flow charts, table structures, interfaces, definitions, timings, storage, and the source listings etc.

(4) For off-the-shelf software packages, which shall be part of the completed application software, the off-the-shelf software package's detailed documentation shall be supplied.

(5) Control software shall support the operator with online help.

(d) Hardware Final System Proposal

(1) The hardware final system proposal shall be written in conjunction with the standard items for the component processor and associated peripherals. If any of the hardware shall be designed or modified for this specification, the specified technical details shall be defined. The proposal shall include a detailed description of the processor system, the method of connection of the peripherals and the transfer of information, including the data transmission system. A full breakdown of the equipment shall be prevented with physical layout, interconnections, and power supply arrangements.

5.1.18 Acceptance Testing

1) All test specifications and schedules for acceptance tests to be performed at the various stages shall be finalized during the final system proposal stage. These shall form the basis on which detailed test procedures can be written.

2) Hardware tests: All hardware test schedules shall be defined. This definition shall include reviews and modifications from the Contractor's standard factory tests if required. A review of the standard diagnostics shall be undertaken.

3) Software and system tests: This shall include all acceptance tests to be performed on the individual programs and the complete system. Detailed test specifications, schedules for all tests described elsewhere in these specifications and any other tests as necessary for

demonstration of the performance, correct operation of the system, etc. shall be provided. The sequence of tests and the grouping of equipment for each test shall also be defined.

5.1.19 Manuals for Operation and Maintenance

1) To maintain the liaison between the Contractor's organization and the engineer, documentation concerning each part of the specifications shall be produced as part of each component job / work, in such a form which can be issued immediately.
2) The Contractor propose a modular system for the build-up of this information.
3) Sections issued during the contract shall be regarded as a draft form, as subsequent jobs shall inevitably interact and require modification, documentation is vital even if several re-issues are necessary.
4) The Contractor's proposal shall include provision for resources to produce the documentation throughout the contract.
5) Effort shall be given on recording and familiarity with the presentation of information maintained, by writing documentation issued during the contract in a form suitable for inclusion in the relevant final manuals.
6) A copied set of the standard proprietary documentation of all the equipment supplied under this contract shall be provided within the first five months of the contract. It will be acceptable if such standard documentation is submitted as part of the documentation forming the final system proposal. But finally, a number of at least 5 copied sets shall be handed over to the employer.

5.1.20 Final Documentation – System Manuals

1) The final documentation shall consist of the following parts:
   - Software manual
   - Programming manual
   - Hardware, maintenance and servicing manuals, including all equipment
   - Tunnel Operator's Manual
2) Where appropriate, standard documentation and project documentation submitted during the contract shall be included in the final system manuals.
3) Not less than six weeks before the commencement of the site acceptance tests, three draft issues of the final system manuals shall be submitted to the engineer for information and approval. This draft issue shall have the same number of parts and format as the final system manual. Re- issues shall be provided if site commissioning and tests make this necessary.
4) When approved, one copy of the draft documentation, amended as required, shall be returned to the Contractor.
5) Six complete sets of the final system manuals together with six copies of complete subject index shall be supplied before the issue of the taking over certificate (acceptance certificate).

5.1.21 Software Manual

1) The software manual shall be project oriented.
2) The software manual shall include the system's programs and the system's data records. Standard detailed programming assistance shall be left to the programming manual.
3) The information shall follow the specification of the final system proposals.
4) The manual shall explain the overall software structure with flow charts and descriptions, with particular attention to the points at which further user programs can be interfaced.

It shall be essential that the complete operating structure is explained in such a way that it may be clearly understood, especially by any competent programmer who wishes to specify or interface a new program into the system. Each program shall have a general description with a related flow chart.

5) In the overall description, the allocation of the addressable storage of the component's jobs shall be listed, with limits of spare capacity. A detailed description of each component's job in the operating system shall follow, including the executive-, handler- and user-programs (the newest version and inclusive updates).

6) The format of all data structures shall be described as a second part to the manual. The data records of diagram formats, variables etc., shall be listed in a form compatible with the data updating system.

7) Source listings for all software supplied, including standard and application program libraries, form part of this manual, except for off-the-shelf software packages for which only a right of use can be purchased.

5.1.22 Hardware, Maintenance and Servicing Manual

1) The manual shall contain a description of the complete hardware system followed by maintenance procedures. The maintenance procedure for tunnels shall contain that in case of maintenance or accidence, the tunnel management shall be done manually by the maintenance people at the Control Centre. For standard equipment, proprietary documentation shall be included.

2) The hardware description shall start with the overall configuration of the system, with layouts showing the location of every unit, with block diagrams and explanation of the operation.

3) Detailed descriptions of component units shall explain their operation. Block diagrams (showing the flow and interaction of data), logic diagrams, circuit diagrams (with component values) and layout diagrams including cabling diagrams (showing the interconnection between equipment) shall be provided. Part- and cable-lists shall be provided, but care shall be taken to avoid these obscuring the operational description. Maintenance procedures shall cover the diagnosis of faults, testing and set-up adjustments, replacement of units, routine mechanical servicing and operation of test equipment.

4) The use of test programs shall be explained with step-by-step instructions. The detailed listing of the programs itself shall be provided separately.

5) Step-by-step description for the replacement of plug-in units of the computer system shall be given, with set-up values and checking of power supply voltages etc. where appropriate. Routine mechanical service shall be covered.

6) Sections on the following equipment shall be bound in separate volumes, as indicated below, for easier use by the maintenance personnel:

- All Low-Voltage Power Supply
- All Lighting
- All Ventilation Equipment
- All Air Control System and Ventilation Control System
- All Fire Detection System
- All SCADA System
- All Room Ventilation and Climate Conditioning
- Control Centre

5.1.23 Tunnel Operator's Manual

1) This manual shall be written specially for use by the tunnel operators at the Control Centre. It shall consist of specific sets of procedures and instructions necessary for effective operation of the system.

2) The manual for the Control Centre shall include:

a) Step by step instruction for fault conditions, fire alarm and all other alarm conditions

b) Step by step instructions on the use of all console equipment. The manual shall be suitable for continuous usage.

5.1.24 Presentation of Documentation

1) All documentation shall be in English language.

2) All documentation shall carry a unique issue number and date.

3) All documentation shall be indexed, with a complete subject index in the final issue.

4) All documentation shall be produced in a uniform format in compliance with the employer's requirements. All diagrams relating to the final documentation shall be reduced to page height, bound and correctly referenced to the text.

5) The final documentation shall be delivered in durable hard cover-bindings. The bindings shall be in a loose-leaf form (ring-binders) and permit easy interchange or replacement of pages. Each ring binder shall be identified by an easily readable title / attached to both, the front face and the spine of the ring-binder.

6) Seven copies of each document shall be provided.

5.1.25 Contractor's Drawings

1) The Contractor shall submit drawings in such a form as the engineer will require them for approval, copies as required of all drawings, diagrams and details of all equipment in part or in whole. The Contractor shall make any drawings available to the engineer at all reasonable times. Wiring diagrams and other drawings as the engineer deems shall not be finally settled until satisfactory installation and testing has been made, this shall be approved in principle.

2) The Contractor shall submit a schematic block diagram of the equipment showing the manner, in which the functional requirements of this specification shall work together.

3) Before the Contractor begins installing his parts of the contracts, the Contractor himself shall check all civil works ensuring all equipment can be installed.

4) Within one month after the signing of the contract, the Contractor shall submit a schedule including details of numbering, categories and drawing registers / indexes for the production, submission and approval during the period of the contract of drawings and also of any information required for the engineer in connection with the design of the contract works.

5) This schedule shall be suited to the requirements of manufacture, delivery and installation of the contract works to meet the requirements of the contract and shall allow reasonable time (approx. 8 weeks) for study and approval by the engineer of all drawings, calculations and graphics submitted (and as necessary, resubmitted) by the Contractor.

6) No approval by the engineer of any drawing shall relieve the Contractor of any of his obligations of liabilities under the contract or of his responsibility for ensuring that the work is satisfactory done and that all operational requirements shall be met.

7) The Contractor shall provide drawings without undue delay, and in any case within twelve weeks of the award of the contract, these drawings shall include dimensions of equipment to be located in equipment rooms and details of cable routes and recesses / outlets, entry of equipment to cabinets, etc.

5.1.26 As -Built Drawings

1) Preparation of the as-built drawings shall be part of these specifications. As-built drawings will be revised final design drawings of the project showing the actual work done.

2) The Contractor shall provide the as-built drawings in one original and one reproducible negative produced from the original, with the names of the signature authorities of the employer, the engineer and the Contractor. After they are signed for approval, five prints shall be taken from the signed original of each drawing. Also DVDs with all as-built drawings shall be handed to the employer.

3) Together with the as-built drawings, the Contractor shall provide six sets of reduced size (e.g. A3 size) booklets of the as-built drawings. All details, dimensions, texts, etc., on the reduced size drawings shall be clearly recognizable and readable.

4) The Contractor shall complete and obtain the engineer's approval on the as-built drawings and make the final submission of the as-built drawings together with the A3 size booklets latest within three months following the date of the Certificate of Completion.

5) All costs associated with the provisions mentioned above shall be deemed to be included in the contract price.

6) As-built drawings shall cover in general:

a) For mechanical equipment:

i. Construction drawings,

ii. Instruction drawings,

iii. Functional block diagrams

b) For electrical installation:

i. Installation drawings with circuit numbers and exact type-assignation of all installed equipment,

ii. Distribution diagrams with circuit numbers,

iii. Fault analysis and protection co-ordination settings the of protection system,

iv. Power consumption,

v. Precise type numbering

vi. Earthing systems

c) For distribution cabinets:

i. Construction drawings,

ii. Circuit drawings as operating diagrams,

iii. Additional current flow-charts where required,

iv. Accurate lists of any installed equipment with precise description of this equipment,

v. Adjustment tolerances of circuit-breakers, switches, etc.

d) For equipment:

i. Construction drawings,

ii. Circuit diagrams,

iii. Functional block diagrams,

iv. List of quantities

e) For cabling:

i. Diagrams with dimensions, type of cables and power requirements with regular cross-

section area and measured cable values shall be used for these diagrams.

5.2 Technical specifications

5.2.1 33 KV SYSTEM

1. General

a) 33 KV GIS substations shall be constructed at the tunnel portal by client. 33 KV cables will terminate at 33 / 11 KV grid substation. The 33kV switchgears assembly having CTs, PTs, Isolators, and circuit breakers shall be kept indoors.

b) The assembly shall have the following configuration:

- 2 nos. incomers for 33 KV cables from SEB
- 1 no Bus coupler
- 2 nos. outgoings for 33/11 KV transformers

c) 33 KV switchgear panel shall be 3 phase combined & single bus type. CT ratio shall be X/1 amp and PT shall be 33000/√3 Volt / 110/√3 Volt. All the panels shall be operated and monitored through SCADA. Substation shall be capable to be controlled locally as well as from remote.

d) 33 KV panels shall be controlled by 24-volt DC, by lead acid battery. The batteries shall be charged with an independent charger.

e) There is one no. 33/ 11 kV grid substation at each portal end of North-south corridor.

2. Scope of work

a) The high voltage supply system shall include the delivery, installation, required works, tests and all necessary equipment for the following materials:

- 33 kV Switchgear (panels / cubicles)
- 33 kV cables
- Protection System
- Transformers
- Accessories
- Potential equalization connection
- Wiring – Signalling for 33Kv

3. Technical Specification -33kv Gas Insulated Switchgear

a) The insulated, medium voltage switch gears shall be designed to equip indoor HV/MV, MV/MV or MV/LV Substations. The switchgear shall meet the criteria for indoor metal enclosed metallic partitioning, LSC2 accessibility GIS switchgear and control-gear for rated voltages above 1kV and up to and including 52kV, in compliance with the IEC 62271-200. In principle, the arrangement shall follow the latest modern engineering practice, to ensure optimum continuity and reliability of supply, as well as the safety of the operating staff. Design shall consider minimum space requirements, no maintenance in medium voltage part and minimized maintenance in the mechanisms. The switchgear shall be of modular design and minimized dimension gas insulated type (SF6).

b) The switchgear shall be designed for continuous operation under all system operating conditions including sudden change of load and voltage and short circuits within its ratings. The equipment shall be designed to withstand normal operating voltage even if the isolating gas pressure decreases to atmospheric pressure. All switchgears and material provided with them shall be the standard products of the manufacturer, which are regularly designed, manufactured, tested and serviced for at least 15 years.

4. System Parameters

Rated Voltage (System Highest Voltage)	36kV
Rated Power frequency withstand voltage	70kV
Rated lightning impulse withstand voltage	170kV
Frequency	50Hz
No. of phases	3
System fault current (Sym.)	25 KA for 3 sec.

5. SERVICE CONDITIONS:

a) Switchgear shall meet the operating conditions, for indoor applications, according to the IEC 62271-1 standard where the environment:

- Minimum temperature: : 15ºC
- Maximum temperature: : 35ºC
- Altitude: : up to 900 m
- Maximum relative humidity : 55 to 85%

6. Compartment Arrangement, Functional Units

a) The switchgear shall be single busbar system. Each cubicle shall have the next compartments:

b) General Busbar compartment - tool accessible – touch proof solid insulated System (screened and earthed) containing:

- Main busbar, segregated phases
- Bus Mounted CT-s if applicable
- Bus Mounted VT-s if applicable
- Three position Disconnector (Closed-Open-Ready to earth)

c) CB compartment - non withdrawable and accessible - SF6 Gas Insulated Containing:

- Vacuum Circuit Breaker
- Three position Disconnector (Closed-Open-Ready to earth)
- MV Cable connection bushings

d) MV cable compartment - interlock accessible - in Air

- MV cables connection points
- Cable Side CT-s if applicable
- Line VTs as per as per IEC 62271-200- if applicable

7. MV Compartment

a) The switchgear shall be modular type. The Loss of Service Continuity class (LSC) shall be 2A (LSC2A) for all functional units. Gas insulated compartments must be segregated in each cubicle and from cubicle to cubicle by means of gas tight barriers. The busbar shall be insulated with single phase solid insulation, shielded and earthed through the entire switchboard making impossible any phase-to-phase fault and having the same advantages as the Gas insulated Busbars systems.

b) The general degree of protection must be IP-65 for all MV parts. All the cubicles must be factory filled and tested to assure a gas leakage of less than 0.1% per year, sealed FOR LIFE pressure system and guarantee no gas handling at a site during extension, removal and

installation at site. SF6 gas used for insulation must comply with IEC 60376 / IS-13072-2013 and IEC 60480. The design of the switchgear shall be such as to enable extensions to be added at either right or left side, with the minimum of disturbance to the installed equipment. Every current-carrying part of the switchgear including Disconnector, Busbars, Connections and joints shall be capable of carrying its specified rated normal current continuously and in no part shall the temperature rise exceed the values specified in relevant IEC Standards.

c) Every part of the switchgear shall also withstand without mechanical or thermal damage the instantaneous peak currents and rated short-time currents pertaining to the rated breaking capacity of the switchgear.

8. Functional Type Requirement

a) Each functional unit shall contain all the elements needed to perform its function. Each functional unit shall be identified by a label which clearly indicates its functional and electrical characteristics.

b) The functional units shall be the following:

- Incoming / Outgoing feeder function.
- Bus-tie function (consisting of bus coupler and bus riser cubicles).
- Load Break Switch Disconnector cubicle.
- Busbar VT-s and CT-s will not need any specific cubicle and must be capable of being connected directly to the general busbar system.
- Load Break Switch Disconnector with associated fuses.

9. Construction/Architecture

c) Busbar Compartment

- Placed on the top part, inside the SF6 compartment.
- Containing main copper busbar system
- Containing also the 3 position Disconnector.
- Disconnector operating mechanism must be placed out of the SF6 gas atmosphere.

d) Circuit Breaker Compartment

- SF6 insulated compartment containing gas tight barriers.
- Containing also the 3 position Disconnector.
- Disconnector operating mechanism must be placed in the front of the switchgear and out of the SF6 gas atmosphere. Rear operation not acceptable.
- Containing Vacuum breaking technology CB.
- Placed on the middle side of the cubicle.
- CB operating mechanism must be placed in the front of the switchgear and out of the SF6 gas atmosphere. Rear operation is not acceptable.
- Low voltage cables going through MV compartments are not acceptable.

e) Cables Connection

There is one type of cables connection for GIS switchgears:

- Outer cone bushings.
- Threaded connection. “C” type bushings according to EN 50181, IS2099, IS10314, IS-5621, IEC-60137 standard.

f) Cables Compartment

- Placed in the bottom rear part of the cubicle. Front access is a must with enough room

for cable connection, rear access is not acceptable.

- Containing Connection points for the above-mentioned cable connectors (refer to "CB compartment")
- Optionally it might contain ring type current transformers
- Optionally it might contain VT-s connected to the above-mentioned outer cone type bushings.
- Containing also cable clamps and the earth connection for the cubicle enclosure.
- All MV components inside this compartment shall be insulated, shielded and this shield connected to earth.

10. LV Compartment

a) Placed in the top front part of the cubicle, front access complete front access to all elements permits the installation of the cubicles close to the rear wall. Each cubicle shall have four levelling bolts in order to provide accurate levelling during assembly. The switchgear shall be constructed of suitable material and thickness to withstand the mechanical and thermal stresses due to short circuits. For the rated duration of short circuit, reference shall be made to the design fundamentals and latest IEC recommendations.

b) Switchgear has to be internal arc withstand classified and the performance shall be as a minimum, IAC AFLR 25 kA as described in the IEC 62271–200 standard. The tanks containing all MV components and filled with SF6 gas shall be made stainless steel of least 2.5mm thick. All the accessible enclosure parts must be conveniently earthed to avoid any risk. All front and lateral panels shall be painted in textured RAL 9002. Rupture flaps shall be provided in main compartment to allow for pressure relief in a non-probable case of overpressure. Each switchgear bay shall be earthed through an appropriate copper earth bar, which is to run also along the full length of the switchgear with a minimum section of $200mm^2$.

c) Numerical relay shall be of modular type and have native IEC 61850 communication support for RTU/SCADA integration. Relay shall be with graphical LCD dot matrix display with single line diagram mimic with control, indication, programmable function key and LEDs.

d) Numerical Relay shall have minimum following protections 50/51, 50N/51N, 46, 86, 50ARC, 50NARC as native function. Arc Flash protection shall be integral part of relay. Protection relay hardware, cables and separate arc sensors shall be included. Any arc flash fault in the cable compartment is selectively cleared by the feeder protection relay.

e) Numerical relay should be with G3 conformal coating and suitable to work in Industrial corrosive environment and should have passed mixed gas test as per IEC 60068-2-60:1995, Part 2, Test, Method (Class 3). The test to include 21 days at 75% relative humidity or 5 days at 90% relative humidity and +30 deg C, exposure to elevated concentrations of H^2S, NO_2 and CI_2.

11. Components

a) Circuit Breaker - Circuit breakers should be Vacuum type. They should be according to IEC 62271-100 standard. Rated operating sequence must be O-0.3Sec-CO-3Min-CO. Operating time for opening, breaking and closing, less than 100ms. Circuit breaker must be E2/M2/C2 type (electrical, mechanical endurance and capacitor breaking/making ability) according to relevant standard. Circuit breaker operating mechanism will be outside the SF6 tank, manually and electrically operated. Vacuum Interrupter shall be tested for min. 100 nos. of full short circuit operations at rated fault level. Vacuum interrupter must be GIS manufacturer's own make and should be type tested design. The operating mechanism should consist in the following items.

- Spring system that stores the necessary energy for opening and closing operation.
- Spring charging system (motor operated) that automatically recharges the springs after the main contacts of the CB have closed.
- Mechanical "charged-discharged" position indicator for CB opening and closing springs.

- Manually operated spring charging system (in case of lack of auxiliary power supply).
- Electrical system including:
  - Closing coil
  - Tripping coil
  - Anti-pumping relay
- Mechanical emergency trip pushbutton.
- Operation counter
- Spring charging indication contact.
- Mechanical indicator for Open / Closed position
- Minimum CB position auxiliary contacts

b) Disconnector

i. The Disconnector is a mechanical device which provides, in the open position, an isolating distance. The Disconnector is always operated with NO LOAD (zero current). The Disconnector will be placed between the CB and the busbar system in order to isolate the busbar system from the circuit side and earth the CB busbar terminals. The Disconnector shall be of three position types, Closed-Open-Ready to earth, in order to avoid the needs of interlocks between the busbar Disconnector and Earthing switch. Separated elements are not acceptable. The Earthing Disconnector will operate always de-energized and the making capacity is provided by the circuit-breaker, which is designed for these purposes.

ii. The Disconnector must be according to the latest edition of the IEC 62271-102 and shall meet requirements as specified RATINGS. The indication of the position of the Disconnector must be mechanical. This mechanical link must be kinematic chain tested. The Operating mechanism must be outside the SF6 atmosphere and accessible from the front.

iii. As the Disconnector is not for operating purposes, the local manual operation by the operator is advisable against the remote-electrical one. Therefore, only manual operation is necessary. The Disconnector must be of single rotation-driving axis both for the Disconnector and the Earthing switch. It is mandatory that the operation from "closed to busbar" to "ready to earth" is made in two separate operations, closed - open and open - ready to earth. These are completely independent operations, with two separated operating access.

c) Busbar - Busbar shall be single phase or three phase SF6 gas encapsulated through the whole switchboard, in order to:

- Maintain the advantages of SF6 insulation not affected by ambient condition.
- Reduce the possibility of a fault due to external cause
- Reduce the dimensions

d) Voltage Transformers

i. Voltage transformers shall be completely touch-proof type suitable for mounting at the cable connection or on the busbar, outside the gas compartment

ii. Instrument transformers shall be suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 45 deg. C.

iii. Feeder voltage transformers must be disconnect-able to **ON-OFF switch inside Gas tank to** perform cable tests without having to remove the transformers.

iv. Busbar voltage transformers must be designed to withstand 80% of the power-frequency withstand test voltage to enable repeat tests at the busbar without having to remove the transformers.

v. Current/voltage sensors, Rogowski coil and or other non-standard arrangements

are not acceptable.

vi. Common characteristics for all transformers:

- Permanent over voltage = 1.2xUn
- Voltage factor = 1.9 x Un/8 hours - 2.5Un peaks.

vii. The following types and mounting possibilities will be accepted:

VT-s for Busbar Voltage metering

Location	Mounting
In Busbar Compartment	Directly connected to the Busbar system (Plug type connection) Over the Busbar. To place 3VT's is needed the wide of two switchgears.

VT-s for Line Voltage metering

Location	Mounting
In MV cables Compartment	Inside the enclosure of the switchgear Connection by a solid isolated plug-in type cable with plug in connectors in both ends.

e) Current Transformer

i. CTs must be ring type and manufactured according to IEC 61869-1, IEC 61869-2 and IS-16227 standards. Transformer's burdens and accuracy classes will be according to the relay characteristics and the protection system characteristics. In accordance with the requirements of currently available relays, the CT-s will be, preferably, with one secondary connection which includes protection and measurement in the same connection. Due to the low power requirements of the digital relays and the closeness between CT and relay, these ones will feature the minimum power output necessary for the protection system. Sensors in place of conventional CT / VT are not acceptable.

f) OPERATION AND INTERLOCKS

i. Common operations in a substation must be available combining different functional units, such as:

- Connect line to busbar.
- Isolate line from busbar.
- Earth the line.
- Couple right busbar section to left busbar section (through bus tie).
- Isolate right busbar section from left busbar section (through bus tie).
- Earth right section of busbar (through bus tie).
- Earth left section of busbar (through bus tie).

ii. The interlock system shall prevent any incorrect operation of the circuit breaker, switches and Disconnector. Mechanical and electromechanical interlocks are preferred over other type of interlocks. There shall be interlocks related to the switchgear itself and also related to all the switchgears in the substation, in order to maintain safety in all operations.

➢ **INTERLOCKS RELATED TO THE SWITCHGEAR ITSELF:**

➢ **DISCONNECTOR**

- Operating handle of the Disconnector can only be removed or inserted once the operation has been completely finished.

- It is not possible to go from "close" position (Disconnector connected to busbar) to "ready to earth" position (Disconnector connected to earth system) in one opera tion.

g) DISCONNECTOR & CIRCUIT BREAKER

i. Disconnector only to be operated with the Circuit breaker in open position.

- Circuit breaker to be maintained in open position while Disconnector is being operated or operating handle is in inserted position.

h) EARTHING THE CIRCUIT

i. A copper / aluminium earth bus of suitable size shall be provided at the bottom extending through the entire length of switchgear. Each stationary unit of the cubicle shall be earthed directly to the earth bus through a contact bar so that the carriage is earthed at all times except when the primary disconnects are separated by a safe distance. Suitable clamp type connectors shall be provided at both ends of earth bus to suit external earthing conductor. Also hinged doors of the cubicle base plate of C/T and P/T shall be effectively earthed. Earth bus shall protrude outside the extreme end panels and by at least by 100 mm.

ii. One set of earthing accessories shall be supplied with the switchgear for earthing of the outgoing side of a feeder or 3 phase bus bars of the switchgear either through earthing facility which comprises truck to be inserted in place of circuit breakers, separate earthing trucks shall be supplied where earthing is achieved through circuit the earth device unless the circuit breaker is in open and isolated position.

- Line earthed position (Disconnector in earth position and Circuit breaker closed) can never be electrically removed. Circuit breakers can only be opened by means of a mechanical push button.
- Line earthed position must have a key lock to assure earth position in all moments.
- Access to the cable compartment will only be possible when the circuit is in an earthed position.

i) ACCESS TO MV CABLE COMPARTMENT

- It will be impossible to access the MV cable compartment unless the cables are conveniently earthed.

Table 1: TECHNICAL DATASHEET – 33kV GAS INSULATED SWITCHGEAR

Sl. No	Description	Technical Parameters
1	Switchboard	
2	Manufacturer's Name	By Bidder
3	Type	By Bidder
4	Standards Followed	IEC 62271-100/200
5	Main Bus bar	
	a) Current Rating	630A
	b) Material	CU
	c) Grade	Electrolytic Cu
	d) Whether Joints are Silver Plated	N.A
	e) Thickness of Coating	N.A
6	Earth Bus bar	
	a) Current Rating	25kA
	b) Material	CU
	c) Grade	Electrolytic Cu
	d) Whether Joints are Silver Plated	N.A
	e) Thickness of Coating	N.A
7	Continuous current Rating for Ambient Condition of site when installed in IP 4X Switch board	
	a) Main Bus bar at Ambient Specified	630A

	b) Tappings at Ambient Specified	630A
8	Temperature rise of Bus bars while	
	a) Carrying rated Current and Installed in IP4X enclosure at an Ambient Temp specified.	As per IEC-60694 Table-V, IS-12729-2004
	b) Under Short Circuit Condition	N.A
	Degree of Protection of Enclosure	SF6 gas chamber- Stainless Steel IP65 Drive-IP2X Low Voltage-IP3X
9	Minimum Clearance in Air	
	a) Between Phases	Since all parts in SF6, clearance is not applicable.
	b) Between Phase to Earth	Since all parts in SF6, clearance is not applicable.
10	Clearance required at the Back & Front of Panel	AFLR: 800 mm @ rear 1700 mm @ front
11	Overall Dimension of the Switch Board (mm)	
	a) Length	In line with Switch Board Configuration
	b) Width	By bidder
	c) Depth	By bidder
	d) Height	By bidder
12	a) Access Height (mm)	
	i) Maximum	By bidder
	ii) Minimum	By bidder
	b) Weight of Panel Board (kg)	
	j) Maximum :	By bidder
	k) Minimum :	By bidder
13	Insulation Level including all the Components	
	a) Power frequency withstand Voltage for 1 min	70 kV
	b) 1.2/50 μ sec Impulse Withstand Level	170 kV
14	Circuit Breakers	
(i)	Manufacturer's Name	
(ii)	Type	
(iii)	Manufacturer's Type reference	
(iv)	Closing Mechanism	spring
(v)	Normal Current rating in Air & corresponding	630A
(vi)	Ambient Temperature	40°C
(vii)	Derating factor for Ambient condition at Site	N.A
(viii)	Service Voltage & Frequency	33 kV, 50 Hz
(ix)	Maximum Voltage at which CB can Operate continuously	36 kV
(x)	Rated Making Capacity	25kA
(xi)	Rated Breaking Capacity	78kAp
(xii)	a) Symmetrical	25kA
(xiii)	b) Asymmetrical	
(xiv)	Short Circuit With stand Capacity	
	a) 3 Sec	25kA
	b) 1 Sec	25kA
(xv)	Total Make time	Within 80ms
(xvi)	Total Break time	Within 60ms
(xvii)	No. of Breaks per pole	1 No.
(xviii)	Total Length of Break per pole	
(xix)	No. of Auxiliary Contacts (NO/NC) for Employer's use	8
(xx)	Type of Arc Control Device	Vacuum
(xxi)	Arc Duration time	

	a) 100 % Load Current	Within 10ms
	b) 10 % Load Current	Within 10ms
(xxii)	Spring Charging Motor	
	a) Type	Universal Motor
	b) Voltage	230 V AC
	c) Rating in kW	By bidder
	d) Protection relay provided	Not Applicable
	e) Protective MCB s provided	Yes
(xxiii)	Power required for :	
	a) Closing	
	i) Momentary	250W
	b) Holding	N.A
	c) Tripping	250W
	d) Time taken for Charging Motor to Charge Spring completely	15 seconds
(xxiv)	Number of consecutive operation the breaker can withstand and the recommended interval between these operations:	O-0.3Sec-CO-3Min-CO
(xxv)	Number of short circuit current interruption after which the breaker requires attention & maintenance	100 @ 25 kA STC
(xxvi)	Number of normal operations after which the breaker requires attention & Maintenance	10000
(xxvii)	Rated capacitor breaking current of breaker/ contactor of each rating	N.A
(xxviii)	Confirm that trip and closing coils will be suitable for 110 V DC and the spring charging motor will be suitable for 240 V AC	Yes
(xix)	Maximum number of XLPE cables & sizes that can be terminated safely in the cable chamber without extension panel	
	a) Single core (Size & No. of Runs)	N.A
	b) Three core (Size & No. of Runs)	Max. 1 cable XLPE Three core 400 sq.mm
(xx)	Maximum no of cables that can be terminated in the cable extension box (Please state the dimensions of such cable extension Box)	N.A
(xxi)	Minimum available distance from the bottom of the panel to the terminals in cable box/chamber for terminating cables	By bidder
(xxii)	Weight of circuit breaker and truck	fixed mounted GIS
15	**Instrument Transformers**	
(i)	Makes	
	a) CTs	By Bidder
	b) PTs	By Bidder
(ii)	Standards followed	IEC / IS
(iii)	Confirm that CTs and PTs will be epoxy resin cast insulated	CT foil, VT metal-cast resin
(iv)	3 second short time current rating of CTs, kA.	25kA
(v)	1 second short time current rating of CTs, kA. :	25kA
(vi)	Dynamic current rating of CTs, kA :	78kAp
(vii)	Confirm that accuracy classes shall be as specified and ratios and capacities shall be as required	Yes/No
(viii)	Confirm that all protective, metering, control and annunciation devices, transducers as specified shall be provided	Yes/No
(ix)	Enclose technical particulars, data sheets, catalogues of all types of relays and other plant being offered by you	Yes/No
16	IP Rating	
	(a) Tank	IP 65 HV part

	(b) Cubicle assembly	IP 3X
17	SF6 Gas Pressure	As per bidder's type tested design
18	Gas Leakage Rate	< 0,1% per year
19	Gas handling Requirement at Site	No Gas handling allowed at site
20	**Cable Terminations**	
	Make	By Bidder
	Type	Outer Cone screen separable connector

TABLE 2: TECHNICAL DATASHEET FOR CURRENT TRANSFORMER

Sl. No.	**Particulars**	**33 kV CT Unit**
1	Nominal System Voltage (KV RMS)	33 **or 0.66KV incase LV CT used**
2	Highest System Voltage (KV RMS)	36 **or 0.72KV incase LV CT used**
3	Frequency	50 Hz
4	Rated Output (V.A. burden)	**As per suitable VA calculation**
5	Rated continuous thermal current	1.2 times of rated primary current
6	Short time current rating for 1 sec	25 kA for 1.0 seconds
7	Rated dynamic current (peak)	2.5 times of short time thermal current
8	Instrument security factor	Less than 5 (five)
9	Impulse withstand voltage (kV peak) (on CT)	170 **or not applicable for LT CT used**
10	Maximum temperature raise over max. ambient temperature of 45°C at rated continuous thermal current at rated frequency and with rated burden	As per IS 2705 / 1992 (part-II)
11	Maximum ratio error	Do
12	Maximum phase angle error	Do
a	Type	Dry type epoxy resin cast
b	No. of cores	One
c	Rated continuous thermal current	As per IS 2705 / 192
d	One minute power frequency voltage withstand test on secondary winding	3 kV
e	Class of accuracy	**0.5S or as per approved SLD**
f	Secondary termination	S1 & S2 shall be clearly engraved
g	Primary termination	P1 & P2 shall be clearly engraved

TABLE 3: TECHNICAL DATASHEET FOR POTENTIAL TRANSFORMER

Sl. No.	**Particulars**	**33 kV PT Unit**
1	Nominal System Voltage (KV RMS)	33
2	Highest System Voltage (KV RMS)	36
3	No. of phases	3
4	Frequency	50 Hz
5	Transformation ratio (PT ratio)	33 kV / 110 V / √3 V
6	Rated Output (V.A. burden)	50 VA per phase
7	Impulse withstand voltage (kV peak) (on assembled PT)	150
8	One minute power frequency dry withstand voltage (on assembled PT set Primary (KV RMS) Secondary (KV RMS)	 70 3
9	Class of accuracy	0.2
10	Rated voltage factor and time	1.2 times continuous and 1.5 times for 30 sec.

11	System conditions	Effectively earthed system
12	Maximum temperature raise over maximum ambient temperature (which may be taken as 45)	Within limits of IS 3156 with latest amendments/revision
13	Maximum ratio error	Do
14	Maximum phase angle error	Do

5.2.2 11 KV System

1. General

a) There is a 11 KV GIS panel in the 33 KV grid substation at each portal The 11 KV GIS panel configuration shall have following feeders as per SLD drawing.

b) At Grid station(North and South Portal):

i. 11KV GIS Panel (Grid)

- nos. incomer from 2 nos. Power transformers through 11 KV XLPE cable.
- nos. incomer from 11KV DG Sync Panel through 11 KV XLPE cable.
- 1 no. bus coupler.
- 2 no. outgoings for Ring feeder 1 & 2
- 2 no. Spare feeders
- 11 KV GIS panel (For DG System) will have following feeders:
- 2 nos. incomers from 2 nos. DG Sets through 11 KV XLPE cable.
- 2 no. outgoings to 11KV GIS Panel(Grid)
- Spare feeders

2. Scope of Work

The high voltage supply system shall include the delivery, installation, required works, tests and all necessary equipment for the following materials:

- 11 kV switchgears (panels / cubicles)
- 11 kV cables
- Protection system
- Instrument Transformers
- Accessories
- Potential Equalisation connections
- Wiring and signalling for 11kV

3. Technical Specification – 11kV GIS (11kV GAS-Insulated, Switchgears)

(A) Indoor 11kv Modular, Gas-Insulated, Switchgears

(a) BASIC SWITCHGEAR DESIGN

i. A metal-enclosed, gas-insulated switchgear according to the currently applicable standards and provisions, prefabricated and type-tested, as single busbar system with stationary switching devices is to be implemented.

ii. The switchgear shall consist of modules, to be aligned side by side, to minimize the number of components subject to high electrical loads. The individual modules correspond to the single line, and the function units described below. The modules must also be connected so that the entire busbar assembly is completely enclosed in SF6 gas atmosphere. Possible extension: on both sides. The IEC classes of the applicable standards and regulations must be specified in the offer and proved by test records.

(b) ECOLOGICAL CORRECT CONSTRUCTION

i. The switchgear must satisfy to a high degree the ecological requirements in view of environmental protection.

ii. The consumption of material and energy during production is to be minimized in an optimum fashion. This applies especially to the utilization of insulating material. Ecologically safe, low-maintenance operation with a service life of min. 30 years must be possible. Use of recyclable materials for efficient and complete (100%) disposal at the end of the service life must be proved by a utilization data sheet. The offer must be accompanied by a certificate confirming that the quality requirements acc. to DIN ISO 9001 have been complied with. After the course of operational switchboard life, it must be possible to recover the complete SF6-gas of every gas-filled compartment by a serial recover valve. Special equipment of the switchboard supplier for recovering is permitted.

(c) GAS COMPARTMENT TECHNOLOGY AND GAS COMPARTMENT MONITORING

i. The cladded gas compartments must be filled with the insulating gas SF6 and be designed as hermetically sealed pressure system according to IEC 60694 (IEC 62271-1), IS-12729-2004. The switchgear's high degree of leak- proofness regarding gas is to ensure that no insulating gas has to be added during the expected service life of the switchgear, under the normal operating conditions specified for indoor switchgear units. The complete busbar system, a central element of the switchgear, must be integrated completely and throughout within the gas-filled cladded compartment of the switchgear. The gas compartments are monitored via pressure gauges with remote signaling contact.

ii. To ensure maximum reliability and availability of the switchgear, the number of gas compartment seals, of static bushings and pressure relief devices must be kept to a minimum. All three breaker poles of a switching device should have a common, gas-tight rotary bushing. The gas compartments must be welded, and all static bushings must be sealed by pressure gaskets for operational life. The operational leak rate for gas insulation must not exceed 0.1 % per year and manufacture to guarantee no gas handling at a site during extension, removal and installation of at site.

(d) PRESSURE RELIEF FOR THE CLADDED GAS COMPARTMENTS

i. The pressure relief device of each gas-filled cladded compartment should be affected via appropriate relief devices into a pressure relief area on the underside of the module. This pressure relief area must be partitioned against the cable connection compartment using a metallic cover. The preferred direction for pressure relief is, from the cable connection compartment to the bottom / top rear, and from the gas compartment of the module tank to the top rear / bottom. Appropriate flooring ducts are prepared by the Customer according to the Contractor's specifications before switchgear installation on site.

(e) DESIGN

i. The switchgear must be designed with extremely small dimensions and for minimum space requirements.

(f) LOW-VOLTAGE CABINET

i. Each function unit is to be equipped with a separate, closed, fully shrouded and arc-resistant low-voltage cabinet with mechanical and electrical interface to accommodate digital protection relays and secondary equipment for control, measurement and counting/metering. The torsion-resistant door can accommodate devices. The dimensions of the low-voltage cabinet have a minimum height of 600 mm and a minimum depth of 350 mm. For transport reasons the low-voltage cabinet must should be easily removable and mountable. Mechanical drive elements must not be installed in the low-voltage cabinet.

(g) ON-SITE INSTALLATION AND POSSIBLE EXTENSION

i. The individual modules or cubicles must be designed so that they can be lined up on site

without any problems or work involving gas bottles. The in-line modular design is to reduce assembly time as much as possible. The specifications dictate that the switchgear must be designed so as to allow for subsequent extension without problems, without requiring interventions into the existing modules. This must be documented conclusively, e.g. by operating manuals and installation instructions.

(h) INTERNAL ARC CLASSIFICATION (IAC)

i. The switchgear to be offered must be checked successfully for internal arc classification. To this effect, the currently applicable standards and provisions must be complied with. The proven short-circuit current must be at a minimum related to the value of the rated short-time current 25kA. The short-circuit duration is 3 s. The test report must be shown with the offer. The following arcing locations must have been realized in the scope of successful testing: gas-filled cladded compartment, preferably in the area of the outer cone-type bushings for cable connection busbar area / coupling chamber between the modules cable connection compartment.

(i) INTERLOCKING SYSTEM

To ensure maximum operator safety, the switchgear must be equipped with a comprehensive interlocking system of excellent design. This interlocking system is to integrate the cable connection compartment and the HVHRC fuse compartment systematically. Actuation of the mechanical operating lever should follow the interrogation interlock principle.

(j) MECHANICAL INTERLOCKS

i. The interlocking system regarding mechanical operating lever actuation must be designed according to the interrogation interlock principle. This means that an operating lever can only be inserted or that actuating forces may only act on the components if this is permitted by the appropriate operating condition of the function unit in question. Digital switchgear interlock units are not accepted by the Customer due to their high costs and as these systems depend on the switchgear's auxiliary voltage.

ii. The interlocking system used should comply with the following interlocking conditions, depending on the equipment installed:

- Double-acting interlock between busbar isolator and outgoing earthing switch
- Double-acting interlock between busbar isolator and circuit-breaker
- Double-acting mechanical interlock between the switch disconnector and the outgoing earthing switch
- Double-acting interlock between the cable compartment cover and the outgoing earthing switch(es) (for cable testing, specific equipment must be provided to eliminate the outgoing earthing)
- Double-acting mechanical interlock between the coupled outgoing earthing switches and the metallic fuse covers
- The fuses are only accessible when the earthing switches are ON
- The front cover can only be closed if the fuses are inserted correctly
- It must only be possible to remove or insert actuating levers in clearly defined positions

(B) "CLOSE" or "OPEN"

(a) VOLTAGE DETECTING SYSTEM ACCORDING IEC 61243-5(CAPACITIVE VOLTAGE INDICATOR)

The test for zero voltage is performed by a plug-in Voltage Detecting System (VDS), which complies with the applicable standards and provisions. Coupling is affected from capacitive voltage dividers in the cable connection areas. Appropriate connections must be provided to enable phase comparison; these are covered in normal operating

condition.

(b) TRANSFORMERS (VOLTAGE / CURRENT TRANSFORMERS)

Inductive current and voltage transformers with minimum amounts of insulating material must be used. It must be possible to operate all commercially available, digital protection relays with the transformers.

(c) CURRENT TRANSFORMER

CT is to be equipped in the outgoing circuit of the circuit-breaker units, with low-voltage ring core current transformers which are separately accessible in the cable connection compartment and which must be mounted outside of the gas compartment onto the extended outer cone-type bushings. Retrofitting or replacing of the current transformers is possible without intervention in the gas compartment from the switchgear front side. The measuring and protection cores are located in a common transformer block. For normal current measurement, the switch disconnector unit can be equipped with one cable-type current transformer per phase. These transformers are located in the metal-enclosed cable connection compartment. The power ratings of the cores must be dimensioned according to the measuring and protection equipment connected to them.

(d) VOLTAGE TRANSFORMERS

1) Metal-enclosed or metallized, touch proofed and grounded inductive voltage transformers should be used. Voltage transformers on the busbars are directly plug-in to the switchgear outside of the gas- filled compartments.

2) Instrument transformers shall be suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 45 deg. C.

3) Feeder voltage transformers must be disconnectable using a ON-OFF switch to perform cable tests without having to remove the transformers.

4) Busbar voltage transformers must be designed to withstand 80% of the power-frequency withstand test voltage to enable repeat tests at the busbar without having to remove the transformers.

5) Current/voltage sensors, Rogowski coil and or other non-standard arrangement are not acceptable.

6) HT Fuse are not acceptable for Voltage Transformer.

(e) CORROSION PROTECTION AND PAINTING

Corrosion-prone steel components of the switchgear cubicles – unless they are made of stainless steel – must be protected by zinc phosphate. Large-sized front components visible from the outside, such as doors or covers, should be coated additionally by scratch-proof textured paint. The colour coating should be provided in the colour RAL 7044 (silk grey).

(f) CIRCUIT BREAKER

i. Circuit breakers should be Vacuum type. They should be according to IEC 62271-100 standard. Rated operating sequence must be O-3 Min-CO-3 Min-CO. Operating time for opening, breaking less than 80ms and closing, less than 60ms. Circuit breaker must be E2/M2/C2 type (electrical, mechanical endurance and capacitor breaking/making ability) according to relevant standards. Vacuum Interrupter shall be tested for min. 100 nos. of full short circuit operations at a rated fault level. The circuit breaker operating mechanism will be outside the SF6 tank, manually and electrically operated. Vacuum interrupters must be GIS manufacturer's own make and should be type tested design. The operating mechanism should consist in the following items.

a) Spring system that stores the necessary energy for opening and closing operation.

b) Spring charging system (motor operated) that automatically recharges the springs

after the main contacts of the CB have closed.

c) Mechanical "charged-discharged" position indicator for CB opening and closing springs.

d) Manually operated spring charging system (in case of lack of auxiliary power supply).

e) Electrical system including:

f) Tripping coil

g) Anti-pumping relay

h) Mechanical emergency trip pushbutton.

i) Operation counter

j) Spring charging indication contact.

k) Mechanical indicator for Open / Closed position

l) Minimum CB position auxiliary contacts

(g) DISCONNECTOR

i. The Disconnector is a mechanical device which provides, in the open position, an isolating distance. The Disconnector is always operated with NO LOAD (zero current). The Disconnector will be placed between the CB and the busbar system in order to isolate the busbar system from the circuit side and earth the CB busbar terminals. The Earthing Disconnector will operate always de-energized, and the making capacity is provided by the circuit-breaker, which is designed for these purposes.

ii. The Disconnector must be according to the latest edition of the IEC 62271-102 and shall meet requirements as specified in RATINGS. The indication of the position of the Disconnector must be mechanical. This mechanical link must be kinematic chain tested. The Operating mechanism must be outside the SF6 atmosphere and accessible from the front.

iii. As the Disconnector is not for operating purposes, the local manual operation by the operator is advisable against the remote-electrical one. Therefore, only manual operation is necessary. The Disconnector must be of single common rotation-driving axis both for the Disconnector and the Earthing switch. It is mandatory that the operation from "closed to busbar" to "ready to earth" is made in two separate operations, closed - open and open - ready to earth. These are completely independent operations, with two separated operating access.

(h) BUSBAR

Busbar shall be single phase solid insulation, screened and earth through the whole switchboard, in order to:

i. Reduce the SF6 quantity in all cubicles.

ii. Maintain the advantages of SF6 insulation not affected by ambient condition.

iii. Reduce the possibility of a phase-to-phase fault.

iv. Reduce the dimensions.

v. Provide the possibilities of installing measuring instruments directly in the busbar system.

(i) EARTHING THE SYSTEM

1) A copper / aluminium earth bus of suitable size shall be provided at the bottom extending through the entire length of switchgear. Each stationary unit of the cubicle shall be earthed directly to the earth bus through a contact bar so that the carriage is earthed at all times except when the primary disconnects are separated by a safe distance. Suitable clamp type connectors shall be provided at both ends of the earth bus to suit external earthing conductor. Also hinged doors of the cubicle base plate of C/T

and P/T shall be effectively earthed. Earth bus shall protrude outside the extreme end panels and by at least by 100 mm.

2) One set of earthing accessories shall be supplied with the switchgear for earthing of the outgoing side of a feeder or 3 phase bus bars of the switchgear either through earthing facility comprises truck to be inserted in place of circuit breakers, separate earthing trucks shall be supplied where earthing is achieved through circuit the earth device unless the circuit-breaker is in open and isolated position.

(j) LOW-VOLTAGE EQUIPMENT

1) INDICATION AND ALARMS: All the specific indications and alarms, which are relevant for the switchgear, must be wired to terminals.

2) REMOTE CONTROL: The remote control for the switching devices in the motor drive must be designed as lockable via a REMOTE ON-OFF switch. Each function unit concerned must be equipped with a remote on-off change-over switch.

3) NUMERICAL RELAY:

a. Numerical relay shall be of modular type and have native IEC 61850 communication support for RTU/SCADA integration. Relay shall be with graphical LCD dot matrix display with single line diagram mimic with control, indication, programmable function key and LEDs.

b. Relay shall have adequate following protections (50/51, 50N/51N, 46, 86, 50ARC, 50NARC as native function). Arc Flash protection shall be an integral part of relay. Protection relay hardware, cables and separate arc sensors shall be included. Any arc flash fault in the cable compartment is selectively cleared by the feeder protection relay.

c. The relay should be with G3 conformal coating and suitable to work in Industrial corrosive environment and should have passed mixed gas test as per IEC 60068-2-60:1995, Part 2, Test Ke, Method (Class 3). The test to include 21 days at 75% relative humidity or 5days at 90% relative humidity and +30 deg C, exposure to elevated concentrations of H2S, NO2 and CI2.

4. 11KV RING MAIN UNIT (RMU)

(1) GENERAL SPECIFICATIONS

i. RMU type, metal-enclosed indoor switchgears, shall be compact switchboard and comply to the following requirements:

- Easy to install
- Safe and easy to operate
- Compact
- Low maintenance

ii. The RMU shall be capable of operating normally within the following temperature range:

- Maximum air temperature: + 40 ° C
- Minimum air temperature: - 5 ° C

iii. RMU to operate in air temperature higher than + 40 °C and the level of air temperature for which current derating is necessary.

iv. The RMU shall be capable of being operated in electrically exposed locations.

v. The RMU shall be capable of being exposed to high relative humidity and ambient air pollution.

vi. The RMU shall be capable of being installed in either concrete indoor substations or in compact metal substations and kiosks with an IP67 rating.

(2) FUNCTION REQUIREMENTS

vii. The following functions shall be available:

- Feeder with switch-disconnector
- Transformer protection with vacuum circuit breaker

viii. Enclosure:

The RMU enclosure shall be made up of CRCA of 2 mm thickness. The high-voltage gas vessel shall be made up of non-magnetic stainless-steel grade SS304 or higher with minimum thickness of 2.5mm. The rating of enclosure shall be suitable for operation on three phases, three wire, 11 KV, 50 cycles, A.C. System with short-time current rating of 21 kA for 3 seconds with Panels. The complete RMU enclosure shall be of degree of protection IP 54. The enclosure shall provide full insulation, making the Switchgear insensitive to the environment like temporary flooding, high humidity etc. The active parts of the Switchgear shall be maintenance-free, and the unit shall be minimum -maintenance.

ix. The Switchgear and Switchboards shall be designed such that the position of the different devices is visible to the operator on the front of the Switchboard and operations are visible.

x. The RMU metal parts shall be made of high thickness high tensile steel which must be treated with 7 tank treatment and subsequently painted with pure polyester, the overall paint layer thickness shall be 100 microns (+/- 25 Micron).

xi. Configuration requirements

a) Extensible range:

b) function unit:

c) Switch-disconnector - Switch-disconnector - Transformer protection with vacuum circuit breaker

d) The RMU shall meet the criteria for compact, metal-enclosed indoor switchgear in accordance with

e) IEC 62271-200:

f) Switchgear classification: PM class

g) Loss of service continuity class: LSC2

h) It shall include, within the same metal enclosure, the number of MV functional units required for connection, power supply and protection of transformers.

(3) RMU BUSHINGS AND CABLE TERMINATIONS

(a) Bushing

i. It is preferable to have all bushings accessible from the front of the RMU and should be site replaceable type. Bushings along the sides or the rear of the RMU are not acceptable.

ii. For each cable compartment, the bushing shall be at the same height in order to facilitate a possible reversal of the cables

iii. The bushing should be conveniently located for working with cables specified and allow for the termination of these cables:

- 630 A M16 bolted connectors for switch-disconnectors and vacuum circuit breakers functions
- 200 A plug-in connectors for transformer protection feeder with fuse combination.

iv. The profiles of the cable connection bushings shall be in compliance with IEC-60137, IS-2099, IS-10314, IS-5621, IEC-60137 standard.

v. A cable clamp arrangement must be provided for all network cables terminated on the RMU.

(4) PADLOCKING FACILITIES

Circuit breakers, fuse-switches combination, switches and earthing switches can be locked in the open or closed position by at least 1 padlock.

(5) VOLTAGE INDICATORS AND PHASE COMPARATORS

i. Each function shall be equipped with a voltage indicator box on the front of the device to indicate whether or not there is voltage in the cables. The capacitive dividers will supply low voltage power to the lamps.

ii. Three inlets can be used to check the synchronization of phases.

iii. This device shall be in compliance with IEC 61958 standard or IEC 61243-5.

(6) FAULT PASSAGE INDICATORS (FPI)

i. The FPI shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The FPI should be self-powered and should have internal lithium battery for external indication and setting of FPI in the absence of current.

ii. The FPIs shall include:

iii. Fault detection - Phase to phase and Phase to earth faults.

iv. One potential-free output contacts for hardwiring to RTUs. On this basis, the SCADA will be able to monitor phase / earth fault condition.

v. Local fault indications - LCD display on FPI front panel along with LED indication on front panel of RMU enclosure.

vi. Multiple reset option –

- End of time delay
- Remote reset (Via potential free input contact of FPI)
- Manual reset (Reset button on front panel of FPI)
- Automatic reset on current restoration.

vii. The characteristics of the FPIs shall include:

- Phase fault thresholds configurable from at least 100 to 800 A
- Earth fault thresholds configurable from at least 20 to 200 A
- Multiple number of steps for adjusting phase and earth fault thresholds.
- Fault current duration range configurable

viii. RMU should have VCB and interrupter of the same make of the RMU .

(7) SAFETY OF PEOPLE

Any accidental overpressure inside the sealed chamber will be limited by the opening of a pressure limiting device in the lower part of the enclosure. Gas will be released to the rear or the bottom of the switchboard away from the operator. Manufacturer shall provide type test report to prove compliance with IEC 62271-200 Annex A, Internal arc classification class AFL with 21kA for 1s for the SF6 tank and cable box..

(8) OPERATING LEVER

An anti-reflex mechanism on the operating lever shall prevent any attempts to reopen immediately after the closing of the switch or earthing switch. All manual operations will be carried out in the front of the switchboard.

(9) FRONT PLATE

i. The front plate shall have suitable IP degree of protection. The front shall include a clear mimic diagram which indicates the different functions.

ii. The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator.

iii. The lever operating direction shall be clearly indicated in the mimic diagram.

iv. The manufacturer's plate shall include the switchboard's main electrical characteristics.

(10) CABLE INSULATION TESTING

i. It must be possible to test the core or the sheath insulation of the network cables while the busbar remains energized at rated voltage. The phase by phase testing shall be carried out through a built-in facility or through the cable connectors.

ii. In order to avoid any risk of bad reassembly, it shall not be necessary to dismantle any earthing bar to perform this operation

(11) REMOTE CONTROL OF THE RMU'S

i. A limited number of applications for remote operation of the RMU are required.

ii. Remote operation of the RMUs line switches must be possible using motors fitted to the operating mechanism.

iii. It shall be possible to fit the motors either directly in the manufacturing plant or on site when required. Installation on site shall be possible with the RMU fully energized and the manufacturer should provide detailed instructions for installation to the control mechanism. Auxiliary contacts for remote indication of switch status are also required.

iv. The fitting of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches. An auxiliary contact to prevent the motorized operation of the mechanism while the operating handle is inserted into the operating point must also be provided

v. The device shall be fully designed for use in a hot, humid atmosphere and shall be low-maintenance. All metallic parts shall have rust protection.

vi. Two lifting rings shall be installed on the top of the switchboards for handling.

(12) TYPE AND ROUTINE TESTS

i. The switchboard, to comply with the following tests (but not limited to):

a) Impulse withstand test,

b) Temperature-rise test,

c) Short time withstand current test,

d) Mechanical operation test,

e) Checking of degree of protection,

f) Switch, circuit breaker, earthing switch making capacity.

g) Switch, circuit breaker breaking capacity.

h) Internal arc withstand

i) Checking of partial discharge on complete unit

ii. The test certificate to conform to NABL accredited testing lab certificate for carrying out internal inspection and testing. The manufacturer must carry out testing of the panel at NABL accredited testing lab or international lab.

iii. The routine tests shall be backed by test reports and include the followings to conform with drawings and diagrams,

a) Measurement of closing and opening speeds,

b) Measurement of operating torque,

c) Checking of filling pressure,

d) Checking of gas-tightness,

e) Checking of partial discharges on individual components,

f) Dielectric testing and main circuit resistance measurement.

(13) 11kV SWITCHBOARDS

a) The switchgear and busbar shall meet the "sealed pressure system" criterion in accordance with the IEC 62271. The manufacturer certificate shall confirm that maximum leakage rate is lower than 0.1 % / year.

b) It shall provide full insulation, for switchgear insensitive to the environment (temporary flooding, high humidity, etc.), IP67 degrees of protection in accordance with recommendation IEC 60529 § 14.2.7.

c) The switchgear shall be maintenance-free and the switchboard shall be low-maintenance.

d) The switchboards shall be suitable for IP protection.

e) The cable compartment shall integrate:

i. Adjustable cable fixing devices

ii. Earth connecting point

iii. Metal partition between cable compartments and tank pressure relief area.

f) The cable compartment shall be arc resistant and suitable for the following cable connecting systems:

i. Partial insulated cable connectors

ii. Fully screened cable connectors

iii. Metal enclosed cable connectors according to DIN EN 50181, IS-2099, IS-10314, IS-5621 and IEC-60137.

g) The colour shall be RAL 7035 as approved for the enclosure and mimic panel.

h) The switchgear and switchboards shall be designed so that the position of the different devices is visible to the operator on the front of the switchboard and operations are visible as well.

i) In accordance with the standards in effect, switchboards shall be designed so as to prevent access to all live parts during operation without the use of tools.

(14) EARTHING OF METALLIC PARTS

a) There shall be continuity between the metallic parts of the switchboard and cables so that there is no electric field pattern in the surrounding air, thereby ensuring the safety of people.

b) The substation frames shall be connected to the main earth busbar without dismantling any bus bars.

(15) EARTHING OF THE MAIN CIRCUIT

a) The cables shall be earthed by an earthing switch with short-circuit making capacity, in compliance with IEC 62271-102 standard. The earthing switch can only be operated when the switch is open.

b) The earthing switch shall be fitted with its own operating mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action.

c) Mechanical interlocking systems shall prevent access to the operating shaft to avoid all operator errors such as closing the earthing switch when the switch is closed.

(16) FEEDER WITH SWITCH-DISCONNECTOR

a) They shall be maintenance-free. The position of the power contacts and earthing contacts shall be clearly visible on the front of the switchboard. The position indicator shall provide positive contact indication in accordance with IEC 60265-1 & IS-9920 (Part-1)-2002 standard. In addition, manufacturer shall prove reliability of indication in accordance with IEC 62271-102 § 6.105 standard.

b) The switches shall be of the "increased operating frequency" in accordance with IEC 60265-1 § 3.104 standard. They shall have 3 positions, open-disconnected, closed and earthed, and will be constructed in such a way that interlocking prevents unauthorized operations. The switch-disconnector and earthing switch shall be equipped with two separate operating entry points.

c) Manual opening and closing will be driven by a fast-acting mechanism, independent of operator action.

d) Each switch can be fitted with an electrical operating mechanism in a specially reserved location, by addition of a motorization unit and without de-energizing the switchboard.

e) The switch and earthing switch operating mechanism shall have a mechanical endurance of at least 1000 operations.

(17) TRANSFORMER PROTECTION WITH VACUUM CIRCUIT BREAKER

a) The circuit breakers shall be of the maintenance-free, vacuum type. The position of the power and earthing contacts shall be clearly visible on the front of the switchboard. The position indicator shall provide positive contact indication in accordance with IEC 62271-102 standard and prove reliability of indication in accordance with IEC 62271-102 § 6.105 standard.

b) An operating mechanism can be used to manually close the circuit breaker and charge the mechanism in a single movement. An independent mechanism shall be fitted for the 3-position earthing switch and disconnector and include a local system for manual tripping by an integrated push button. The operating sequence of vacuum circuit breaker must be O-0.3sec-CO-3min-CO and mechanical endurance shall be 10000 nos of operation without any maintenance.

c) The circuit breaker shall be associated with an integrated protection unit that will operate without any auxiliary power supply and shall include:

i. Three toroidal transformers incorporated in the transformer tee-off bushings for protection and metering,

ii. An electronic relay (Self Powered)

iii. A low energy release

iv. A system protection testing (with or without CB tripping)

(18) MV METERING

a) MV Metering shall be carried out by a factory assembled.

b) Connection with adjacent cells will be direct through bus bar but MV cables shall be possible.

c) VT's and CT's to comply with type DIN 42600 standards and IS-3156, IS-2705, IS-16227 and the following configuration shall be available:

i. VT's phase-earth

ii. -1 nos. Aux VT , 1ph, 500VA, 11KV/230V AC

(19) FEEDER REMOTE TERMINAL UNIT (FRTU)

a) The RMU remote control interface shall include all the functions required to monitor and control LBS and VCB in RMU.

b) Since, requirement is for Motorized RMU ,and looking at integration issues same vendor to supply FRTU and RMU and support for integration of FRTU with Scada, in order to avoid teething technical issues of integration while execution.

c) The monitoring and control enclosure shall meet following main requirements:

i. Monitoring and control of medium voltage cubicles.

ii. Detection of amperometric faults, adjustable for each feeder.

iii. Load current measurement to the SCADA.

iv. Data transmission to the remote control centre.

v. It shall be possible to view the most important information locally on the front panel of the enclosure and remotely from the control centres.

vi. Possible to retrieve and display on a laptop PC the time-stamped events recorded at the

vii. enclosure. Possible to retrieve information from the remote control centre also.

viii. Event storing capacity.

ix. Local remote switch

d) In remote control mode, the enclosure shall ensure:

i. Transmission of remote measurements and time-stamped events.

ii. Possibility of electrical remote control.

iii. Inhibition of local electrical control pushbuttons.

e) In local mode, the enclosure shall ensure:

i. Transmission of remote measurements and time-stamped events.

ii. Possibility of local electrical control of opening and closing operations by simultaneously pressing a pushbutton to select the unit to be operated and a validation pushbutton.

iii. Inhibition of opening/closing remote control.

(20) FRTU POWER SUPPLY:

a) Power from FRTU shall be sufficient to supply 24 V to at least all the switch cubicles.

b) The standby energy shall be provided by a 12 V 24 Ah battery / as approved with a minimum autonomy of at least 9 hours for 10 opening and closing cycles.

c) The FRTU power supply shall be protected against over voltages and over currents. The dielectric characteristics of the supply voltage input in accordance with IEC 60 25564 shall be available in the station is single-phase 220 V AC.

d) The control unit shall comply with the following communication ports:

i. One Ethernet port for interfacing with IP compatible communication equipment.

ii. One Modbus RS485 port to connect field IED's / Energy Meters on RS485.

iii. One port for connecting external modems.

TABLE: 1 TECHNICAL DATASHEET FOR RING MAIN UNIT (RMU)

Network	Three phases - Three wires
Rated Voltage	12 kV

Service Voltage	11 kV
System Frequency	50 Hz
Lightning Impulse withstand Voltage Phase to phase, phase to earth Across the isolating distance	 75kV 85 kV
Power Frequency withstand voltage	28 kV rms - 1 min
Rated Normal Current Line switch Transformer feeder Branch circuit breaker feeder	 630 A 200 A 630 A
Rated Short time current withstand (3 sec)	21 kA
Internal Arc IAC (SF6 tank and cable box)	21KA for 1 sec with AFLR classification
Rated Short circuit making capacity of line switches and earthing switches	62,5 kA peak at Rated Voltage
Number of operations at rated short circuit current on line switches, earthing switches and CB	5 closing operations
Rated load interrupting current Line switch	 630 A rms
Rated cable charging interrupting current Line switch	 30 A
Number of mechanical operations Line switches and earthing switches Switch-fuse combination Circuit breaker	 1000 O/C 1000 O/C 2000 O/C
Number of electrical operations at full load breaking current	100 O/C
Number of operations at rated short circuit current on circuit breaker	 10 breaking operations

All of the switchgears shall be capable of withstanding this current without any damage being caused, in accordance with the recommendations IEC 62271-1 and IEC 62271-200.

5. Protection System Of 11 KV System

a) For the protection of the high voltage equipment, over current-time protection relay with feeder differential protection for cable connections shall be provided. Backward-lock-out shall shorten the time to trip.

b) During failure of time-overcurrent protection, a selective time interval, which is

another type of protection trips, shall be provided.

c) A synchro-check unit shall be provided for the circuit breakers in the 11 kV feeder and cable panels. With this synchro-check unit the state at switching points shall be controlled for enabling an uninterrupted switching to normal net configuration in case of a failure.

d) All required OFC equipment for the protection system of 11 kV System shall be included in the price of protection system.

6. SPECIFICATION OF PROTECTING SYSTEM:

a) By the protection system of the High Voltage Supply, the Contractor has to take into account, that an Electrical selectivity/discrimination between the individually (sub) stations and the 33 kV-System shall be provided.

b) Basic conditions for the protecting systems are:

i. Selectivity to the 33 kV-System

ii. Selectivity by faults in cables with automatic shift of the disconnecting point to the defect part of the system

iii. Insensitive and reliable protection system for tunnels

iv. Internal data-transmitting via optical fibre cabling

7. CURRENT TRANSFORMER

Current transformers for feeder panel or cable panels shall be three-pole, provided with measuring and protecting core. In the cable panel, toroidal core transformers shall be used provided as a three-phase block-type current transformer. The current transformer load shall be adjusted to the arrangement of protection devices. The secondary terminals shall be situated on the terminal strip inside the panel.

8. VOLTAGE TRANSFORMER

For voltage measuring on the bus bar, three one-pole voltage transformers shall be used.

For cable panels, three one-pole voltage transformers shall be used for measuring and earth- fault detection, with open delta winding. All voltage transformers shall be pluggable, metal- enclosed and shock proofed. The secondary terminals shall be realized by plugs inside the panel. Voltage transformers on the branch shall be removable for cable testings.

9. PROTECTION EQUIPMENT

All functions of the protection equipment shall be microprocessor controlled (microprocessor- based protection and control).

10. AUXILIARY POWER SUPPLY

For the required auxiliary power supply, a connection E&M Contractor's DC power supply shall be included. The power supply of the protection equipment shall be able to span an interruption of the auxiliary supply for ≤ 50 ms. A switching of ON / OFF of the auxiliary power supply shall not cause a malfunction of the protection equipment.

11. PILOT RELAY

For the transmission of signals, the Contractor shall provide enough pilot relays. The assignment of the signals to the relays shall be freely selectable. Also the formation of common signal / common alarm shall be possible. The state of the relays shall survive a failure and recovery of the auxiliary supply.

12. STORAGE OF FAULT SIGNALS AND FAULT VALUES / ALARMS

The formed fault signals in the devices of the last three events shall be stored by SCADA. The beginning of a failure shall be marked with the real-time of the internal system

clock. Within failure the separate signals shall be provided with the relative time with a resolution of 1 ms.

13. DATE AND TIME

All protection devices shall be equipped with integral real-time clock (RTC) inclusive a calendar function. The clock shall be able to be synchronized and equipped with a buffer battery.

14. SELF-MONITORING AND SIGNALLING OF DEVICE-FAULTS

a) All protection devices shall be equipped with monitoring of the hardware and software. Minimum requirement of the monitoring is:

i. Monitoring of the internal auxiliary power supply for digital and analogue circuits

ii. Monitoring of the analogue-to-digital conversion (offset, drift, accuracy)

iii. Monitoring of the command circuit to the coil of the command relays (short circuit and failure / interruption)

iv. Monitoring memory chips by using cyclic formation of checksum and comparing with deposited checksum.

v. Monitoring of the continuous program processing by time monitoring (watchdog)

15. FURTHER REQUIREMENTS

a) The protection devices shall be designed as panel-plug-in devices with screw-type terminals on the back side and covering, and following front side display and control elements (minimal requirement):

i. Illuminated LC-display, (at least) four lines, alphanumeric, for displaying of miscellaneous. information

ii. at least 6 free parametrizable LED displays with labelling field

iii. at least 4 free programmable function keys

iv. 4 navigation keys

v. at least 12 numeric operator buttons

vi. special keys for parameterization

16. OVERCURRENT – TIME PROTECTION RELAY WITH FEEDER DIFFERENTIAL PROTECTION FOR CABLE CONNECTIONS

a) Nominal current: 1 A

b) Nominal voltage: 80 – 125 V

c) Nominal frequency: 50 Hz

d) Auxiliary power supply: 240 VAC

e) Local control:

- 4-lined LCD-display with information text
- Indication and count value
- Operator and control keyboard
- 4 free programmable function keys
- 7 free programmable LEDs

f) Communication:

- Interface RS232 on the front side
- System-Interface on the backside of the device

- Interfaces for optical fibre cables (amount and types depends on used system)

g) General functions:

- Battery-maintained clock
- Fault messages: the last 8 fault messages have to be stored
- Operational message: the last 80 messages have to be stored
- Self-monitoring

h) In-/Outputs:

- 7 binary inputs
- 5 relay outputs
- 1 live contact

i) Protection functions:

- Phase-selective differential protection for two-ending-operation
- Over current-time protection phase I>, I>>, Ip>>
- Breaker intertripping
- Thermal overload protection
- Quick breaking step
- Displaying of measurements for local and distant cable-endings
- Operation by parameters
- Lock-out
- Trigger circuit protection

j) Automatic functions:

- Command conversation
- Filter for messages
- Locking transfer function
- Programmable logical functions

17. OVER CURRENT TIME PROTECTION FOR OUTGOING TRANSFORMER UNIT

a) Nominal current: 1 A

b) Nominal frequency: 50 Hz

c) Auxiliary power supply: 240 VAC

d) Local control: LCD-display for current measurements

e) Communication:

i. Interface RS232 on the front side

ii. System-Interface on backside of device

f) Interfaces for optical fibre cables (amount and types depends on used system).

g) General functions:

i. Battery-maintained clock

ii. Fault messages: the last 8 fault messages have to be stored

iii. Operational message: the last 80 messages have to be stored

iv. Self-monitoring

h) In-/Outputs:

i. 7 binary inputs

ii. 5 relay outputs

iii. 1 live contact

i) Protection functions:

i. Over current-time protection phase I >, I >>, Ip >>

ii. Over current-time protection earth IE >, IE >>, IEp >>

iii. Inrush locking

j) Automatic functions:

i. command conversation

ii. Filter for messages

iii. Locking of transfer function

iv. Programmable logical functions

18. Accessories For 11 KV System

(A) DISTRIBUTED I/O (PROVIDED BY CONTRACTOR OF E&M / SCADA)

Distributed I/O's are required for using the advantages of a double-sided feeding at the 11 kV System. The distributed I/O's will be provided by the Contractor of E&M/SCADA. All data points of the 11 kV-System run to the distributed I/O's .

(B) FIRE EXTINGUISHER

a) CO fire extinguishers shall be provided in E & M Niches, equipment room / Niches substation.

b) The fire extinguishers shall be made of galvanized steel and resistant against frost. Dry powder extinguishers only in rooms with lower voltages than 1 000 V are allowed. So, in the high voltage rooms CO2-fire extinguishers shall be required.

(C) ACCESSORIES FOR 11KV (SUB) STATION

a) Each 11 kV (sub) station shall be equipped with:

i. Single Line Diagram of 11 kV-System of tunnel with glass-covering

ii. Sheet / Board including the instruction for first aid by electrical accidents

iii. Sheet / Board including the instructions for fire-fighting measures in electrical plants

iv. Prescription of operation of High Voltage Systems

v. Suspension Device for accessories

vi. Warning Sign "Attention High Voltage"

vii. Voltage Detector

viii. Earthing Accessories

19. Operation Modes

All switching equipment, which shall be equipped with a remote-control switch, shall need a changeover switch. Therewith a switching between local- or remote-control is possible.

LOCAL CONTROL:

If the changeover switch is positioned at "local control", all up streamed switching equipment has to switch off the remote controlling. The whole switchgear interlocking shall also work at local control.

REMOTE CONTROL:

a) At this position of the changeover switch the user shall be able to choose between different switch possibilities out of a predefined matrix. Generally, it shall be possible to decide which of the two feedings shall be switched.

b) A remote controlling of the high voltage power supply shall only be possible, if:

i. No changeover switch is positioned at local control.

ii. No earthing switch is switched.

iii. No fault is stored.

Table 5: TECHNICAL DATASHEET FOR 11KV GAS INSULATED SWITCH-GEAR

Sl. No	Description	Technical Parameters
1	Switchboard	
2	Manufacturer's Name	By Bidder
3	Type	By Bidder
4	Standards Followed	IEC 62271-100/200
5	Main Bus bar	
	a) Current Rating	630A
	b) Material	CU
	c) Grade	Electrolytic Cu
	d) Whether Joints are Silver Plated	N.A
	e) Thickness of Coating	N.A
6	Earth Bus bar	
	a) Current Rating	25kA
	b) Material	CU
	c) Grade	Electrolytic Cu
	d) Whether Joints are Silver Plated	N.A
	e) Thickness of Coating	N.A
7	Continuous current Rating for Ambient Condition of site when installed in IP 4X Switch board	
	a) Main Bus bar at Ambient Specified	630A
	b) Tappings at Ambient Specified	630A
8	Temperature rise of Bus bars while	
	a) Carrying rated Current and Installed in IP4X enclosure at an Ambient Temp specified.	As per IEC-60694 Table-V, IS-12729-2004
	b) Under Short Circuit Condition	N.A
	Degree of Protection of Enclosure	SF6 gas chamber-Stainless Steel IP65 Drive-IP2X Low Voltage-IP3X
9	Minimum Clearance in Air	

	a) Between Phases	Since all parts in SF6, clearance is not applicable.
	b) Between Phase to Earth	Since all parts in SF6, clearance is not applicable.
10	Clearance required at the Back & Front of Panel	AFR: 500 mm @ rear 1700 mm @ front
11	Overall Dimension of the Switch Board (mm)	
	a) Length	In line with Switch Board Configuration
	b) Width	450m/ 600mm
	c) Depth	1400mm
	d) Height	2400/2800mm
12	a) Access Height (mm)	
	i) Maximum	1850 mm height of lock of LV box door
	ii) Minimum	830 mm height of cable box handle
	b) Weight of Panel Board (kg)	
	j) Maximum :	Approx. 900
	k) Minimum :	Approx. 700
13	Insulation Level including all the Components	
	a) Power frequency withstand Voltage for 1 min	28 kV
	b) 1.2/50 μ sec Impulse Withstand Level	75 kV
14	Circuit Breakers	
(i)	Manufacturer's Name	
(ii)	Type	
(iii)	Manufacturer's Type reference	
(iv)	Closing Mechanism	Spring
(v)	Normal Current rating in Air & corresponding	630A
(vi)	Ambient Temperature	40°C
(vii)	Derating factor for Ambient condition at Site	N.A
(viii)	Service Voltage & Frequency	11 kV, 50 Hz
(ix)	Maximum Voltage at which CB can Operate continuously	12 kV
(x)	Rated Making Capacity	25kA
(xi)	Rated Breaking Capacity	63kAp
(xii)	a) Symmetrical	25kA
(xiii)	b) Asymmetrical	27kA
(xiv)	Short Circuit With stand Capacity	
	a) 3 Sec	25kA
	b) 1 Sec	25kA
(xv)	Total Make time	Within 60ms
(xvi)	Total Break time	Within 60ms
(xvii)	No. of Breaks per pole	1 No.

(xviii)	Total Length of Break per pole	
(xix)	No. of Auxiliary Contacts (NO/NC) for Employer's use	8
(xx)	Type of Arc Control Device	Vacuum
(xxi)	Arc Duration time	
	a) 100 % Load Current	Within 10ms
	b) 10 % Load Current	Within 10ms
(xxii)	Spring Charging Motor	
	a) Type	Universal Motor
	b) Voltage	230 V AC
	c) Rating in kW	0.223
	d) Protection relay provided	Not Applicable
	e) Protective MCB s provided	Yes
(xxiii)	Power required for :	
	a) Closing	
	i) Momentary	250W
	b) Holding	N.A
	c) Tripping	250W
	d) Time taken for Charging Motor to Charge Spring completely	8 seconds
(xxiv)	Number of consecutive operation the breaker can withstand and the recommended interval between these operations:	O-0.3Sec-CO-3Min-CO
(xxv)	Number of short circuit current interruption after which the breaker requires attention & maintenance	100 @ 25 kA STC
(xxvi)	Number of normal operations after which the breaker requires attention & Maintenance	10000
(xxvii)	Rated capacitor breaking current of breaker/ contactor of each rating	N.A
(xxviii)	Confirm that trip and closing coils will be suitable for 110 V DC and the spring charging motor will be suitable for 240 V AC	Yes
(xix)	Maximum number of XLPE cables & sizes that can be terminated safely in the cable chamber without extension panel	
	a) Single core (Size & No. of Runs)	N.A
	b) Three core (Size & No. of Runs)	Max. 1 cables XLPE Three core 400 sq.mm
(xx)	Maximum no of cables that can be terminated in the cable extension box (Please state the dimensions of such cable extension Box)	N.A
(xxi)	Minimum available distance from the bottom of the panel to the terminals in cable box/chamber for terminating cables	500mm.
(xxii)	Weight of circuit breaker and truck	fixed mounted GIS
15	Instrument Transformers	
(i)	Makes	
	a) CTs	By Bidder

	b) PTs	By Bidder
(ii)	Standards followed	IEC
(iii)	Confirm that CTs and PTs will be epoxy resin cast insulated	CT foil, VT metal-cast resin
(iv)	3 second short time current rating of CTs, kA.	25kA
(v)	1 second short time current rating of CTs, kA. :	25kA
(vi)	Dynamic current rating of CTs, kA :	63kAp
(vii)	Confirm that accuracy classes shall be as specified and ratios and capacities shall be as required	Pls. refer Technical Offer
(viii)	Confirm that all protective, metering, control and annunciation devices, transducers as specified shall be provided	Pls. refer Technical Offer
(ix)	Enclose technical particulars, data sheets, catalogues of all types of relays and other plant being offered by you	Pls. refer Technical Offer
16	IP Rating	
	(a) Tank	IP 67 HV part
	(b) Cubicle assembly	IP 3X
17	SF6 Gas Pressure	0.6 bar (0.06 MPA)
18	Gas Leakage Rate	< 0,1% per year
19	Gas handling Requirement at Site	No Gas handling allowed at site
20	Cable Terminations	
	Make	By Bidder
	Type	Outer Cone

5.2.3 Transformer

A. 33/11 kV Transformers

a) The transformer shall be installed in the way that no vibration will be transmitted to the building/ construction. The Transformer shall be of _____ kVA, 33/11 kV, oil filled type for normal application.

b) Requirement for two winding transformers with On Load Tap Changing Mechanism: -

The two winding Power transformers shall be Natural Ester oil immersed transformers shall conform to IS 2026, IS-1180 and IEC 62770 standard for Natural Ester Oil filled trans

c) This specification covers design, engineering, manufacture; shop testing, inspection, painting, packing, and supply of Distribution Transformers complete with all accessories for efficient and trouble-free operation of the proposed Substation.

d) The design, manufacture and performance of equipment shall comply with all currently applicable statutory regulations, and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the E & M Contractor of this responsibility. The Quality of Raw material, Manufacturing process & design parameters should meet the requirement so as to ensure quality of transformers former and shall have following specifications:

- The equipment shall conform to the latest edition of applicable standards as follows. In case of conflict between applicable standards and this specification, this specification shall govern.

o IS 2026, for Tests & tolerance on Guaranteed Particulars

o IS:3639 for Fittings and Accessories

- IS:2099 for Bushings > 1000 V
- IS:7421 for Bushings < 1000 V
- IS:1271 for Electrical Insulation classified by Thermal stability

- Transformers shall accept, without injurious heating, combined voltage and frequency fluctuations which produce the 125% over fluxing condition for one minute.

1. GENERAL CONSTRUCTION: -

All material used shall be of best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions, overloads, over excitation, short-circuits as per specified standards, without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

a) Tank:

The exterior of tank and other steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of an oil and weather-resistant nature, preferably of distinct colour from the prime and finish coats. The final coat shall be of a flossy, oil and weather resisting non-fading paint of specified shade. The interior of the tank shall be cleaned by shot blasting and painting with two coats of heat resistant and oil insoluble paint.

i. Steel bolts and nuts exposed to the atmosphere shall be galvanized.

ii. Unless otherwise stated, the tank together with radiators, conservator, bushings, and other fittings shall be designed to withstand without permanent distortion the following conditions:

iii. Full vacuum of 760 mm of Hg, for filling with oil by vacuum.

iv. Internal gas pressure of 0.35 Kg/cm2 (5 lbs/sq.in) with oil at operating level.

v. The tank cover shall be suitably sloped so that it does not retain rainwater.

vi. The material used for gaskets shall be cork neoprene or approved equivalent

b) Core:

Transformer shall be double wound, core type with low loss, non-ageing, high permeability PRIME GRADE, CRGO with M4 Grade or Better, perfectly insulated and clamped to minimize noise and vibrations. Followings should be Mandatory for any Manufacturer: -

i. Transformer shall be of BOLTLESS core design

ii. Core shall be purchased Directly from Manufacturer or from their accredited Marketing organization of Repute & not through any agent. Bidder has to submit manufacturer's name during bidding having sufficient credential & Core has to be purchased from the approved manufacturer.

iii. Stage inspection of the core shall be done at manufacturer's premises & inspection call shall be given with following Documents:

- Invoice of the supplier
- Mill's test certificate
- Packing list
- Bill of landing & Bill of Entry certificate by customs

iv. Transformer manufacturer should have in-house core cutting facilities for proper control & monitoring of quality & to avoid mixing of Prime core with Second grade /defective core materials. Transformer Manufacturer should have inhouse slitting Machine so as, core is cut to width & stacked with minimum air gap thus ensuring Burr level less than 10Microns.

v. Core shall be procured from one of the reputed Manufacturers. The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand a voltage of 2000V for one minute.

c) Windings:

i. Winding shall be made with 99.9% pure electrolytic grade copper, insulated with thermally upgraded paper (Insulation Class A / Conductor Interturn insulation Class E). The HV & LV winding should be able to withstand thermal and mechanical stress in the event of short circuit.

ii. Winding shall be carried in dust free area

iii. The completed core and coil assembly shall be dried in vacuum and shall be immediately impregnated with oil after the drying process to ensure elimination of air and moisture within the insulation.

d) Oil:

i. Transformer oil shall be as per IEC 62770 / IS-1180 - Natural Ester vegetable oil. Oil should be Environment friendly, Green & Biodegradable. It should also exhibit safety against fire hazards.

ii. Oil shall be filtered and tested for break down voltage (BDV) and moisture content before filling.

2. TEMPERATURE INDICATOR: -

One set of winding temperature indicators with necessary current transformer, heating coil and a detector element and one set of oil temperature indicator with maximum reading pointer shall be mounted locally so as to be readable at a standing height from ground level. Each of the above indicators shall be provided with necessary contacts for alarm and trip.

3. TEMPERATURE RISE:

a) The transformers shall be designed for continuous operation at their rated power without exceeding the temperature rise as per IS 2026 – Part 2 & it shall be 50˚C - 55˚C, over an ambient temperature of 45 ˚C. In core and other metallic parts: Temperature shall in no case reach a value that will damage the core itself, other parts or adjacent materials.

b) With the given climatic conditions, the transformers shall be capable of operating continuously on any tap at their normal rating without exceeding following temperature rises:

c) 70° C above ambient temperature for oil.

d) 80° C above ambient temperature for winding.

e) The temperature of a hot spot in winding shall not exceed 130°C when calculated over max. annual weighted average temperature of 35° C.

4. BUCHHOLZ RELAY

The Buchholz relay shall be provided with two floats and two pairs of electrically separate contacts for alarm and trip. The relay shall have facility for testing by injection of air by hand pump and with cock for draining and venting of air. The location of the relay shall be such that all rising gas will readily reach it.

5. BUSHINGS

a) All bushings shall be homogenous, solid porcelain oil commissioning type, uniformly glazed and free from blisters, burns and other defects and shall be furnished complete with suitable terminal connectors of adequate capacity. The bushings shall be located so as to provide necessary electrical clearances between phases and also between phase and ground as specified in relevant standards.

b) Bushings rated for 400A and above shall have non-ferrous flanges and hardware.

c) All bushings shall have puncture strength greater than the dry flashover value.

d) Neutral CTs shall be furnished with its secondary leads wired up to the terminal blocks. The terminals for CT secondary leads shall have provision for shorting. The arrangement shall be such that the CT can be removed from the transformer without removing the tank cover.

The minimum phase-to-phase and phase-to-earth external clearances for LV & HV bushings shall be as per IS 1180 (part-2)

External (Air) clearances between bushings mounted on transformers:

Nominal System Voltage	Phase to Phase clearance in mm	Phase to Earth clearance in mm
Up to 1.1 kV	75	40
11 kV	255	140
22 kV	330	230
33 kV	350	320

Air Clearances in Cable Box

Nominal System Voltage	Phase to Phase clearance in mm	Phase to Earth clearance in mm
Up to 1.1 kV	25	20
11 kV	130	80
22 kV	240	140
33 kV	350	220

6. TERMINAL ARRANGEMNT

a) Low voltage terminals of Power transformer shall be brought out to bushing inside Cable Box

b) High voltage terminals of Power transformer shall be in arrangement to connection of Cable inside cable box

c) The cable box shall be suitable for cable termination kits and shall be self-supporting, weatherproof, air-filled type, complete with all hardware such as gland plate, brass glands, tinned copper lugs, armour clamps etc.

7. MARSHALLING BOX

a) A sheet steel weatherproof marshalling box of IP 55 construction shall be mounted on the tank of transformer and shall accommodate all auxiliary devices except those which must be located directly on the transformer. All terminal blocks for external cable connections shall be located in this box. The terminal blocks shall be ELMEX 10 mm2 or approved equal.

b) The marshalling box shall have the following as a minimum:

i. Loads disconnect switch for incoming power supply for auxiliaries.

ii. All outgoing connections from transformer viz. Buchholz relay, temperature indicators, fault contacts for annunciation system etc.

iii. Wiring and termination points individually of the following trip contacts for remote alarm and trip.

- Winding temperature high / very high
- Oil temperature high / very high
- Buchholz relay Alarm / Trip
- Oil level low

c) Cubicle illumination lamp with door switch and space heater with thermostat and ON/OFF switch shall be provided.

d) Marshalling box shall be designed to facilitate external cable entry from bottom. Removable gland plates shall be furnished with double compression type brass cable glands.

e) Sufficient space shall be provided to avoid sharp bending and for easy connection of cables. A minimum space of 200 mm from the gland plate to the nearest terminal block shall be provided.

f) Wiring shall be done with HR PVC 650 V grade wires. The wire size for CT circuits shall be 4 mm2 copper and for other circuits shall be a minimum of 2.5 mm2 copper. Not more than two (2) wires shall be connected to a terminal. 10% spare terminals shall be provided.

g) All devices and terminal blocks within the marshalling box shall be identified by symbols corresponding to those used in applicable schematic or wiring diagrams.

8. GROUNDING

a) Two grounding pads, located on the opposite sides of the tank, shall be provided for connection of Switchyard ground mat for each transformer. Grounding pads shall have clean buffed surface with tapped holes. M10 G.I. bolts, nuts and spring washer shall be provided.

b) 2 Nos. Ground terminals each shall also be provided on marshalling box, cable box & OLTC panel to ensure effective earthing.

c) The Neutrals of the windings shall be brought out through neutral bushings at suitable location. The neutrals shall be suitable for connecting 75x10 mm Copper flat.

d) For conductivity of earth connection, all gasketed joints shall be provided with minimum two nos. of copper strip of adequate size.

9. ON Load Tap Changing Mechanism

a) Should be Separately mounted out tank type (CTR make)

b) Should comprise of 20 Steps / 21 Positions: +10% to -15% @ 1.25%

c) RTCC & AVR to be supplied along with the OLTC.

d) OLTC shall be as per following:

i. The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded i.e. 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.

ii. When a tap change has been commenced it shall be completely independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.

iii. Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released

from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. An Oil surge relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.

iv. Oil, in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valve pipe connections. Any gas leaving these compartments shall pass through the Buchholz relay before entering the conservator.

v. Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection opening with gasketed and bolted cover with lifting handles.

e) OLTC driving mechanism and its associated control equipment (local) shall be mounted in an outdoor, weatherproof cabinet with IP 55 protection which shall Include: -

i. Driving motor (433V, 3-phase, 50 Hz. AC squirrel cage).

ii. Motor starting contactor with Motor Protection Circuit Breaker, isolating switch and HRC fuses.

iii. Control switch: Raise/off/lower (spring return to normal type).

iv. Remote/local selector switch (maintained contact type).

v. Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.

vi. Limit switches to prevent motor over-travel in either direction and final mechanical stops.

vii. Brake or clutch to permit only one tap change at a time on manual operation.

viii. Emergency manual operating device (hand crank or hand wheel).

ix. A five-digit operation counter.

x. Electrically interlocked reversing contactors (preferably also mechanically interlocked).

xi. 240V, 50 Hz. AC space heater with switch and HRC fuses.

xii. Interior lighting fixture with lamp door switch and HRC fuses.

xiii. Gasketed and hinged door with locking arrangement.

xiv. Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.

xv. Necessary relays, contactors, current transformers etc.

f) Control requirements for OLTC: The following electrical control features shall be provided:

i. Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.

ii. Only one tap change from each tap change impulse even if the control switches or push button is maintained in the operated position.

iii. Cut-off of electrical control when manual control is resorted to. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.

iv. Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

g) Automatic Control of OLTC: Automatic OLTC control shall include the following items:

i. Voltage setting device.

ii. Voltage sensing and voltage regulating devices.

iii. Line drop compensator with adjustable R and X elements.

iv. Voltage setting device.

v. Voltage sensing and voltage regulating devices.

vi. Line drop compensator with adjustable R and X elements.

vii. Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.

viii. Adjustable dead band for voltage variation.

10. OLTC Panel:

a) The OLTC remote control equipment shall be suitable for 30V DC supply and shall be housed in an indoor sheet cubicle to be located in a remote-control room. The OLTC control panel shall comprise of rigid welded structural frames made of structural steel section or of pressed and formed cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2 mm. Stiffeners shall be provided wherever necessary. All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. Panel shall be dust, weather and vermin proof providing degree of protection of IP54, colour of finish shade for interior and exterior shall be Powder Coated RAL7032 respectively. Earthing bus shall be of 25 x 6 mm copper.

- Control switch: Raise/ Off/ Lower (spring return to normal type)
- Auto/manual selector switch: (Maintained contact type)

b) Tap Position indicator:

i. Facia type alarm annunciator with “accept” and “lamp test” facilities.

- A.C. supply failure
- Drive motor auto tripped
- Tap change delayed

ii. Necessary auxiliary relays

iii. Lamp indications for:

- Tap change in progress
- Lower limit reached
- Upper Limit reached
- Cable glands for power and control cables
- 240 V rated panel space heater with ON-OFF switch
- Fluorescent type interior lighting fixture with lamp and door switch
- HRC fuses
- Terminal blocks
- Internal wiring
- Earthing terminal
- Supply ON Indication Lamp.
- Labels for Accessories.
- Automatic Voltage Regulating Relay.
- Heater Switch (Rotary Type)
- Control Supply Switch (Rotary Type)
- Hooter for Facia annunciator (230V AC)

- Time Delay Relay for 'Tap Change Delayed' (110V AC)
- H.V. Voltmeter (Digital Type)
- H.V. Voltmeter Selector Switch (Rotary Type)
- L.V. Voltmeter (Digital Type)
- L.V. Voltmeter Selector Switch (Rotary Type)
- PT for AVR.
- Tap changer Counter for registering

11. Valves

a) Valves shall be of forged carbon steel above 50 mm and of gun metal for sizes upto 50mm. They shall be of full way type with screwed ends. They shall be opened by turning counter clock-wise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.

b) Every valve shall be provided with open/close position indicators. The valves shall be suitable for pad locking in open/close positions. All screwed valves shall be furnished with pipe plugs for protection.

c) All valves shall be provided with flanges having machined faces drilled to suit the applicable requirements.

d) Oil tight blank flanges shall be provided for the following.

e) valves opening to atmosphere.

f) for each connection for use when any radiator is detached.

g) Any special radiator valves tools required shall be supplied by the bidder.

h) The Transformer shall provide with Nitrogen Fire Protection system so as to envisage complete safety from Fire Hazards

12. TESTS:

The tests listed below shall be carried out and shall be deemed to be included in the BIDDERS scope. E & M offer shall include prices for carrying out all tests as specified.

a) ROUTINE TESTS – The manufacturer should have NABL accredited test lab.

i. Measurement of winding resistance

ii. Measurement of voltage ratio and check of voltage vector relationship

iii. Measurement of impedance of voltage (principal tapping), short circuit impedance and load loss.

iv. Measurement of no-load loss and current

v. Separate source voltage withstand test

vi. Induced overvoltage withstands test (2 times the rated voltage)

vii. 2kV withstand test for all wiring

viii. Magnetic Balance Test

b) TYPE TESTS

i. Pressure & Vacuum test needs to carry out on 1unit of each rating

ii. Noise level test needs to carry out on 1 unit of each rating.

iii. Heat run and Impulse test shall be carried out on 1 unit of each rating…

iv. Short circuit report of similar / higher rating not older than 3 years

c) ACCEPTANCE TESTS

i. One transformer of each rating, selected randomly from the lot shall be sent for measurement of losses, declared by vendor (on data sheet) at third party / any NABL accredited lab.

ii. Oil Leakage test for acceptance shall be conducted at pressure of 0.35kg/sq.cm for one hour.

iii. Checking of weights, Dimensions, fitting and accessories, tank sheet thickness, oil quantity, material, finish and workmanship, Physical verification of core coil assembly and measurement of flux density on one unit of each rating of the offered lot with reference to the GTP and contract drawings.

iv. Temperature rise test on one transformer selected randomly to be sent at NABL accredited lab at Contractor cost. If transformer fails, the test or found to be under rated the contract shall be terminated as per clauses of contract agreement.

13. LOSSES:

Losses shall be as follows: -

a) Respective Current density & Flux Density shall be to suit the required No load & loss levels

b) All the measurement of losses shall be carried out by digital meters of class 0.5 or better accuracy and should be certified by the manufacturer. If the losses measured are found to be out of tolerance band as stated in Standard and guaranteed losses declared by manufacturer, the same shall be attributed to the manufacturer as per capitalization formula till the end of warranty period.

c) One transformer of each rating, selected randomly from the lot shall be sent for measurement of losses, client reserves rights of cancellation & replacing equipment of proper specification by E & M Contractor to comply as per contract agreement terms / condition

B. 11/.433 kV Distribution Transformers

1. SCOPE OF SUPPLY & SERVICES

The scope of work for the "Distribution Transformers" and associated items covered under this specification shall include but not limited to the following:

a) Design, engineering, procurement, manufacture, fabrication, shop testing and inspection, supply, packing and forwarding, transportation to site, Unloading, Erection and Commissioning of Transformers.

b) All materials supplied under this contract shall be new and unused.

c) Inspection and expediting, handling, packing, forwarding, transporting, documentation including submission and approval of drawings, Commissioning, and performance testing of equipment.

d) Engineering of all the systems covered in this specification, including preparation and submission of detailed drawings & documents / calculations / reports as detailed and quantification of entire items included in scope.

e) Submission of drawings, documents, test certificates & calculations for information / approval of the PURCHASER / CONSULTANT, as elaborated elsewhere in this document, including those required for submission to Chief Electrical Inspector of Government.

2. System Design Basis

a) The insulation requirement of transformer windings shall be: -

Normal voltage (kV)	0.433	11
Highest system voltage kV (RMS)	1.1	12

Lightning impulse with stand voltage kV (peak)	-	75
Short duration power frequency withstands voltage kV (RMS)	3	28

b) DUTY REQUIREMENT

i. The transformer and all its accessories like current transformers, bushings etc., shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 2 seconds. Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.

ii. Source short circuit levels to be assumed for design with an operating time duration of 3 sec:

At 33 kV : 25 kA

At 11 kV : 25 kA

At 0.433 kV : 50 kA

iii. Transformer shall have mechanical and thermal capabilities for withstanding the short circuit current for the specified duration without any damages.

iv. All the transformers shall be designed for the following over fluxing withstand capability:

110% : Continuous

125% : 10 seconds for Distribution Transformer

v. The transformer shall be capable of being loaded in accordance with specified standards. There shall be no limitation imposed by bushings, tap-changer etc.

vi. The overload capacity of the transformer and their emergency short time ratings called for in schedule shall be furnished.

3. IMPEDANCE

The percentage impedance voltage at principal tapping on the ratio primary /secondary MVA base shall be as per technical data. The impedance shall be without negative tolerance.

To achieve the above percentage impedance value, no reactor either inside or outside the tank shall be used.

4. LOSSES

i. Loss figures shall be guaranteed, without positive tolerance.

ii. The no load loss in kW at the rated voltage and frequency and the load loss in kW at the rated voltage, rated frequency, rated output and at 75 Deg. C shall be quoted and these figures shall be guaranteed.

iii. If the test figures exceed the quoted values, the transformer will be rejected.

iv. The transformers shall be installed in that way, that no vibrations will be transmitted to the building / construction. The connecting of the 11 kV-cables at the transformers only shall occur with right-angle connectors. Those right-angle connectors shall be calculated into the price of the 11 kV-cable.

C. DRY TYPE 11 / 0.433 KV TRANSFORMER (INDOOR PORTAL / NICHES SUBSTATION)

1. SPECIFIC REQUIREMENTS FOR DRY TYPE TRANSFORMERS

a) Temperature rise of winding measured by Resistance: 90 deg C

b) Constructional Features

i. The transformer shall be of cast resin encapsulate type, but shall be naturally cooled

(AN) and moisture proof. Insulating materials used in construction shall be of non-inflammable. The transformer shall be housed in enclosure fabricated from sheet steel of minimum 2mm thick. Degree of protection for the enclosure shall be at least IP33. Screen shall be perforated sheet steel type. Mesh size shall be such that lizards, rats etc. cannot enter inside the enclosure.

ii. The enclosure shall be adequately reinforced to ensure rigidity so as to permit transportation of transformer within enclosure. Base frame for moving the transformer shall be min. 4mm thick and shall be provided with bi-directional rollers/mounting skid.

iii. Double leaf access shall be provided with concealed hinge and neoprene gaskets for easy access to H.V. links and also for withdrawal of core and coil assembly if required.

iv. Enclosure shall be provided with lifting lug and grounding terminals. Further the enclosure door shall have provision of padlocking in door-closed position. The door should be easily but firmly lockable.

v. For all dry type transformers, following safety interlocks shall be provided:

- A safety interlock shall be provided to ensure that the enclosure door can be opened only when transformer is de-energized.
- Safety limit switches operated by door handle shall be provided for tripping HV & LV side breaker.

vi. Similarly, the outer surface shall also be cleaned of all scale and then the primary coat shall be applied, immediately after cleaning. The second coat shall be of epoxy paint of shade conforming to Siemens Grey – RAL 7032.

vii. Steel bolts if used, shall be parkerised. Terminal screws, studs, nuts and bolts shall be of non- ferrous material, threaded conforming to IS.

viii. All fasteners exposed to weather shall either be nonferrous/Heavy duty type CPF/ZPF or hot dip galvanized or electroplated conforming to relevant I.S.

2. Core

a) Core, its supporting steel and insulation shall be of such design, material and construction that harmful changes in electrical or physical properties shall not occur during the life of transformer. Limbs and yoke shall have similar section to minimize effects of transverse flux. Butt joints between yoke and limbs shall not be made. Generous cooling ducts shall be provided for core heat dissipation to ensure that maximum temp. Rise will not exceed the temperature indicated in the technical data sheet.

b) Core and winding shall be strongly braced, casted and held at respective places to prevent displacement or distortion during transportation or abnormal electrical conditions in service. Core grounding arrangement shall be located at the top for easy access from inspection hole.

3. Windings

a) Each coil shall be high quality fibre glass insulated reinforced with epoxy resin, continuous smooth, high grade, electrolytic copper conductor, without sharp corners or bends and shall be adequately transposed to minimize eddy current losses and equalize current and temperature distribution. Abrasive damage and high dielectric stresses in insulation shall not occur. Similar coils shall be interchangeable. Liberal ducts shall be provided for prevention of 'hot spots' that may affect insulation life. Insulation of windings and other live parts should be adequate to sustain 110% of rated operating voltage continuously.

b) Coil supports shall be by permanently secured, highly compressed and dried regularly spaced insulating spacers. Coil clamping rings, if of steel shall each be earthed by

connection to core clamping structure and shall otherwise be of insulating material built up from flat laminations.

c) Insulating material shall be of proven design. The insulating material shall be glass fibre reinforced conforming to class `F'. Coils shall be so insulated that impulse and power frequency voltage stresses are minimum and are suitable to withstand even the severest to temperature variation. Separate encapsulation for HV and LV winding shall be provided.

d) Winding assembly shall be dried in vacuum, thoroughly shrunk to final dimensions and resin casted. The whole assembly shall finally be held under compression of at least twice the thrust likely to be set up under a terminal short circuit.

e) Design, arrangement, insulation and assembly of the winding on core shall be so as to ensure uniform distribution of voltage surges amongst all coils and minimize stresses in winding due to terminal short circuit. No corona discharge shall result in the winding upon exciting the transformer for specified induced voltage test.

f) Earthing Arrangements: - The core coil assembly shall be directly connected to this ground bus by removable bolted link for effective grounding. Earthing terminals shall also be provided on cable box and marshalling box to ensure its effective earthing.

g) Terminal Arrangement

i. Terminal box shall be of air-filled type. The cable box shall have all standard facilities envisaged for dry type transformer.

ii. Cable boxes shall be designed to accommodate all cable joint fittings or sealing ends as required. The bottom plate shall be of non-magnetic stainless steel, brass or aluminium for all transformers on LV side requiring cable connections. The disconnecting chamber shall be air insulated, removable links and removable covers shall be provided for the disconnecting chamber. Plates through which high current carrying conductors pass, shall be of non-magnetic materials.

h) Off-Circuit Tap Changer

i. The off-circuit tap changing will be effected by change of links for dry type transformers. Arrangement shall be such that the contacts are correctly engaged. A warning plate indicating that change of links for tap changer switch shall be operated only when the transformer is de - energized shall be provided.

ii. All contacts shall be silver plated and held in position under strong contact pressure to ensure low contact drop and avoid pitting.

iii. The design of tap changing link for dry type transformers shall be such as to ensure that same tap is set on the three phase at a time.

i) Bushings / Support Insulators: -

i. Bushings/Support Insulators shall be designed and tested to comply with the applicable standards.

ii. Bushings shall have non- ferrous and non-magnetic flanges and hardware.

iii. Fittings made of steel or malleable iron shall be galvanised.

iv. All bushings/support insulators shall be supplied with terminal connector clamp suitable for supporting the bushing terminal & the PURCHASER'S conductor as specified in data sheet.

v. Minimum air clearance and minimum creepage distances shall be as per data sheet.

vi. Bushing/support insulators material shall be porcelain.

j) Temperature indicator: - Three numbers of programmable winding temperature indicator of digital type shall be provided. The Temperature indicator shall have a separate relay with 2 NO and 2 NC contacts for alarm and trip. The display shall be with

LED type.

k) Marshalling Box

i. Sheet steel vermin and weather proof marshalling box, shall be provided with a controlled metal clad heater to accommodate the following equipment.

ii. Terminal boards and gland plates shall be with suitable glands for incoming and outgoing cables, meant for temperature alarm / trip, annunciation and lamp indication devices for remote panel, etc.

4. TECHNICAL DATA SHEET / PARTICULARS

TO BE SUBMITTED WITH TECHNICAL BID – SCHEDULE – TECHNICAL PARTICULARS

D. **DOCUMENTS TO BE SUBMITTED AFTER AWARD OF CONTRAC**T

i. General outline drawing, showing front elevations and plan views of the transformer and all accessories and external features with detailed dimensions, weights, crane lift for un tanking and for erection / removal of bushings, size of lifting lugs and pulling eyes, HV and LV terminal clearances, live terminal to ground clearance, quantity of insulating oil and dimensional details for foundation.

ii. Terminal box drawings showing disconnection chambers / LT busduct flange.

iii. Assembly drawings of HV, LV and Neutral groundings.

iv. Core earthing details with disconnecting link

v. Detailed calculation for radiator design and cooling fan capacity

vi. Schematic control and wiring drawing and drawings showing temperature indicator circuits and control system for cooling equipment.

vii. Drawing showing construction and mounting details of marshalling box.

viii. Drawing, giving details of name plate, terminal marking and connection diagram.

ix. Drawing on tap changer gear assembly and online OLTC oil filtration system.

x. The magnetisation characteristic curves of the bushing current transformers, indicating the knee point voltage excitation current and secondary resistance.

xi. Drawing on terminal clamps.

xii. Core saturation curves.

xiii. Calculation to demonstrate the ability of transformer to withstand dynamic forces due to short circuit.

xiv. Detailed erection, testing & commissioning, operation and maintenance manuals.

xv. Detailed Instruction for storage of equipment at site.

xvi. GA, Dimensions & Weight of Transformer during shipment.

xvii. Any approval given to the detailed drawings by the PURCHASER shall not relieve the SUPPLIER of the responsibility for the correctness of the design, completeness of the equipment supplied and in the execution of the works in accordance with the terms of specification.

xviii. Additionally, eight (8) sets hard copies of above drawing shall be submitted by the SUPPLIER for Client's approval purpose.

E. TESTING & INSPECTION

1) INSPECTION

a) The accredited representative of the PURCHASER shall have access to the SUB-SUPPLIER's works at any time during working hours for the purpose of inspection of manufacture or testing and selection of samples of the materials going into the

equipment. The SUPPLIER shall provide necessary facilities for such inspection or test.

b) The core and coil assembly shall be offered for PURCHASER's /CONSULANT's inspection prior to tanking and the readiness for such inspection shall be intimated at least 15 days in advance. The tanking of core and coil assembly shall be taken up only after approval by PURCHASER /CONSULTANT.

c) All the type / special / routine tests on the transformers as per of latest issue and indicated below will be witnessed by PURCHASER's / CONSULTANT's Engineers and all necessary facilities for inspection and testing shall be provided by the SUPPLIER. The transformer shall be completely assembled and tested at the SUPPLIER's factory.

d) The SUPPLIER shall ensure that the test instruments have calibration certificate issued by an approved standard laboratory, not earlier than six months from the date of testing.

e) The readiness of the transformers for testing and final inspection shall be intimated to the PURCHASER / CONSULTANT at least 15 days in advancefor deputing Engineers for inspection / witnessing the tests. The transformer

f) will be accepted at site by the PURCHASER's / CONSULTANT's Engineer only on production of the approved test certificates.

2) FACTORY ASSEMBLY AND TESTS

a) The following type tests (to be conducted on any one (1) of the Distribution transformers for each rating as per specified standards shall be carried out in the presence of representatives from PURCHASER / CONSULTANT. The PURCHASER shall have the right to test the transformer at neutral agency or test the transformer at SUPPLIER's works through external agency:

Temperature rise test at the barest tap position at ONAN (Loss figures at corresponding tapping to be considered, for testing).

b) The following routine tests as per specified standards shall also be carried out on the all types of transformers, free of cost.

i. Measurement of winding resistance.

ii. Measurement of voltage ratio and check of voltage vector relationship,

iii. Measurement of impedance voltage / short circuit impedance (principal tapping) and load loss.

iv. Measurement of no-load loss and current.

v. Measurement of insulation resistance.

vi. Dielectric tests (Power frequency voltage test and induced over voltage withstand test).

vii. Oil leakage test on transformer tank: The tank and oil filled compartments shall be tested for oil tightness by completely filling with air / oil of viscosity not greater than that of insulating oil, conforming to specified standards at the ambient temperature and applying a pressure, equal to the normal pressure plus 35 kN/Sq.m measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air during which time no leakage shall occur.

viii. Magnetic balancing test.

ix. Measurement of no-load current with 415 volts supply.

x. Check for polarity and ratio tests for knee point voltage and magnetising current for bushing current transformer.

xi. Measurement of zero sequence impedance.

xii. Measurement of harmonics of the no load current.

xiii. Measurement of tank and capacitance of each winding to earth (with all other windings earthed) and between all windings (connect together) to earth.

c) The test sequence shall be tests on transformer tank, heat run test, pressure test on the assembled transformer, routine tests and special tests.

3) TESTS AT SITE

a) After erection at site, the transformers shall be subjected to the following tests by the CONTRACTOR, who will be engaged by the PURCHASER:

i. Insulation resistance test.

ii. Ratio and polarity test on all taps.

iii. Dielectric test on oil

iv. Open circuit and short circuit test

v. Operation test of OLTC

vi. Operation test of protection devices and interlocks.

b) Measurement of winding resistance at all taps.

c) Any other test as may be insisted upon by PURCHASER / CONSULTANT.

4) TEST CERTIFICATES

a) Six copies of the test certificates on the above type tests / special tests / routine tests with the endorsement of the Inspecting Officer shall be furnished for approval.

b) The test report shall provide the following information:

i. Complete identification data, including serial no. of the transformer.

ii. Method of application where applied, duration, and interpretation of results in each test.

iii. Temperature data corrected to 75 deg. C including ambient temperature.

c) The equipment will be rejected if test results are not in conformity with the Guaranteed Technical particulars.

d) Besides the above test certificates, SUPPLIER / SUB-SUPPLIER's test certificates in respect of the following accessories shall also be furnished in six copies:

i. Off-circuit tap changer

ii. Bushings

iii. Bushing current transformers (with magnetisation characteristic curves)

iv. Buchholz relays & Surge relay

v. Magnetic oil level gauge

vi. Winding temperature controller.

vii. Oil temperature controller

viii. Radiators

ix. Transformer oil

x. Any other bought out components not specifically mentioned herein.

e) The SUPPLIER shall also furnish test certificates to the effect that the transformer core has been tested after assembly and immediately prior to the despatch of the transformer for one minute at 2000 volts AC between all bolts, side plates and structural work.

TABLE 6: TECHNICAL DATASHEET FOR OIL IMMERSED TYPE 33/11KV TRANSFORMER

Rated power	_____KVA as specified / as required
Voltage (primary side)	33 kV
Voltage (secondary side)	11 kV
Nominal Frequency	50 Hz
Cooling	ONAN
Tapping	20 steps (+10% to -15% @ 1.25%)
Internal gas pressure	0.35 Kg/cm2 (5 lbs/sq.in)
Core design	Boltless
Oil	Natural ester vegetable oil as per IEC 62770, IS-1180
Winding insulation	Thermally upgraded paper (Insulation class-A / conductor Inter turn insulation class-E)
Impedance voltage	7.0%
Vector Group	Dyn11
Location	Grid station
Primary connection	Totally insulated plug-in connector
Secondary connection	Connection safe to touch with connecting lug and insulating cover

TABLE 7: TECHNICAL DATASHEET FOR 11/0.433KV DISTRIBUTION TRANSFORMER AT PORTAL AND INSIDE TUNNEL

S. No.	Description	Technical Parameters
1	**GENERAL**	
	Application/designation	Distribution transformer
	Service	Step down transformer
	Type	Dry type cast resin / two winding
	Installation	Indoor
	Degree of protection for transformerswith enclosure as per IS:2147	IP-33
2	**RATINGS**	
	Rating	_____ KVA, _____KVA
	Rated primary voltage	11000 V
	Rated no load secondary voltage	433 V

S. No.	Description	Technical Parameters
	No. of phases	3-phase on HV 3-phase with neutral on LV
	Frequency	50 Hz
	Vector group	Dyn 11
	Percentage impedance	6.25%,5.0%
	Permissible tolerance on impedance	± 10%
	System fault current for 1 secondduration	HV Wdg : 25 kA (rms)LV Wdg : 50 kA (rms)
	Type of cooling	Natural air cooling (AN)
3	**SYSTEM VOLTAGE**	
	Nominal system voltage	11000 V
	Highest system voltage	12 kV for 11 kV winding 1.1 kV for 433 V winding.
4	**NEUTRAL EARTHING**	
	Transformer neutral earthing	LV Winding: Effectively earthed Note:-1) Additional neutral bushing should beprovided for neutral earthing. Note: - 2) Neutral CT Shall be provided for REF Protection .CT Details shall be finalizedduring drawing approval stage.
5	**INSULATION WITHSTAND VOLTAGE**	
	Impulse (1.2/50 μ-sec. wave)	HV Winding : 75 kV peak for 11 kV winding
	One minute power frequency	HV Winding : 28 kV for 11 kV winding LV Winding : 3.0 kV
	Class of Insulation	F
6	**TEMPERATURE**	
	Reference Ambient Temperature (Design)	-15% to 30°C
	Temperature rise by winding resistance at lowest tap (Max)	90°C

S. No.	Description	Technical Parameters
	Temperature on enclosure by thermometer (Max)	50°C
7	**Noise level**	
	Permissible noise level (Max)	73 dB
8	**TAP CHANGING LINKS**	
	Taps required	Off-circuit full MVA rating at each tap
	Type	Bolted link (Tinned copper links)
	Tappings on windings	HV
	Total tapping range	±7.5%
	Steps	2.5%
	Parallel Operation	Momentary with similar transformer.
9	**BUSHINGS/SUPPORT**	
	Voltage class	a) HV line end - 11 kV b) LV line end / LV neutral - 1.1 kV
	Impulse (1.2/50 μ-sec. wave)	HV Winding : 75 kV peak
	One minute power frequency	HV Winding : 28 kV LV Winding / LV neutral : 3.0 kV
	Minimum creepage distance	25 mm / kV
10	**SURGE DIVERTER**	3 nos. of Polymeric Zinc Oxide surge Arrestors (10 kV , 10 kA , line discharge Class-2)
11	**MINIMUM CLEARANCE IN AIR**	
	HV phase to phase	230 mm
	HV phase to earth	180 mm
	LV phase to phase	25.4 mm
	LV phase to earth	25.4 mm
12	**TERMINAL CONNECTIONS**	
	HV line end terminal with HT cable box	Suitable for terminating 11 kV x 300sq.mm XLPE armoured earthed grade cables.

S. No.	Description	Technical Parameters
	LV line end terminal with LT cablebox	Suitable for terminating 0.415 kV x 300sq.mm XLPE armoured earthed grade cables.
	LV neutral bushing	LV neutral bushings as per specification
	PURCHASER's earthing	Two no's of 185 sq mm copper earth conductor
	Colour finish shade of enclosureInterior/ exterior Cable/bus entry (bottom/Top side)	Glossy finished RAL 7032 Bottom for HTCables/Top for LT cables
13	**ENCLOSURE**	
	Details of enclosure material andthickness	As per specification
14	Orientation of HT and LT termination compartments.	90 deg displacement

5.2.4 Diesel Generator Sets

1. Standards

The design, material, construction, manufacture, inspection, testing and performance of the Engine/ Generator sets shall comply with all currently applicable standard, regulations and safety codes in the locality where the equipment shall be installed.

Standards to which the equipment covered in this tender shall be designed, manufactured, inspected and tested are listed below: -

- ISO – 3046 Parts 1 to 4
- BS – 4999 all parts including part 71 / equivalent standards.
- IEC Standards for electrical and electronic equipments.
- A.S.M.E. Boiler and pressure vessel code for welding procedures and welder Qualification for all diesel engine sub systems.
- TEMA Standards for tubular heat exchangers.

2. Scope

a) The specification covers Design, Manufacture and Testing at works of 2 Nos.2000 KVA, 11 KV Prime duty (No standby duty DG is recommended) Diesel Generator sets with associated accessories including Synchronizing Panel, Neutral Isolator / Neutral Grounding Resistor Panel.

b) The D.G. Sets are intended for use as emergency sets to start on AMF (Automatic Start on Mains Failure) and capable of a minimum of 50 - 60% step load and prime power continuous rating as per BS 5514 not less than their rated capacities at 0.8 PF. The speed of D.G. Sets shall not exceed 1500RPM and shall be of four-stroke design for operation on high-speed diesel.

c) The D.G. Sets with Radiator mounted on the skid, shall be capable of achieving 100% rated within 15 seconds of initialling a start& 10% overload for 1hr in every 12hours of operation. The D.G.Sets are intended for operating in parallel with provision for auto

synchronizing and auto load sharing. The offer for the D.G. Sets shall include well designed ventilation and fuel systems, startup batteries with associated chargers, interconnecting piping, system and protection earthling with neutral grounding resistor and isolating facility, local control & AMF, 11 KV DG switchgear, cabling to the switchgear and necessary gadgets for interfacing to Tunnel management system (SCADA) to make the generating system complete in all respects, including acoustic control to meet statutory requirements.

d) The scope of services include delivery at site, positioning on foundation (Civil works will be done by some other agency), erection, testing & commissioning of DG sets with associated 11KV switchgear, running of DG sets on full loads, performance testing of the complete system to prove guaranteed parameters for fuel oil consumption, acoustics and temperature rise, including but not limited to the following.

i. Supply, installation, testing and commissioning of 11KV D.G.Sets Radiator mounted on Skid

ii. Silencers, Exhaust piping including the outlets, insulation up to chimney.

iii. Earthing system (system earthing & protection earthing) with earthing resistor.

iv. Heavy duty antivibration spring type movement for the DG sets including hardware.

v. Pipe lines from Bulk fuel storage tank to intermediate tank, day tanks and spill tank with associated pumps, valves, including necessary level sensors /over flow controls, float valve in each day tank complete with support structures and civil works.

vi. Brush less exciter and voltage regulators

vii. Generator Lubrication systems including pumps, piping, oil coolers, oil filters and reservoir.

viii. RTDs, BTDs and Space Heaters in Alternator (Anti condensation Type) Exhaust Silencers (Residential Type) with Insulation.

ix. AMF and engine instruments and control panel comprising electronic governor, automatic voltage regulator, facility for auto synchronizing, auto-load and VAR sharing, basic minimum engine protection & annunciation, auto synchronizing and breaker control switch.

x. Power DB for auxiliaries, with necessary accessories and interlocks.

xi. DC power supply through adequately rated DC Battery and panel mounted Battery Charger.

xii. Ventilation system as / if required to maintain the temperature of the DG room within 10 degree C + ambient, with all DG sets running continuously.

xiii. Supply and installation of free standing Chimney to connect the Generators.

xiv. Fuel required for load test shall be included.

xv. Post Load testing 990Lts of Diesel need to be filled prior to Handing over.

xvi. All necessary consumables such as Diesel, Oil, Coolant, D.M.Water need to be in Vendors Scope.

xvii. Load Testing 2Hrs.30mins 100% ie.rated kVA capacities need to be performed at Site independently.

xviii. Synch of 4x2000kVA need to be performed and exhibited with 50% load sharing At site.

xix. Each D.G.Sets need to be load tested at 25%- 30mins, 50%- 30mins, 75%- 30mins, 100%- 30mins, 110%- 30mins prior to Synch between both the D.G.Sets.

xx. Post Synch all the D.G.Sets need to run for 1hour in synch mode.

xxi. Preparation of shop drawings and getting approval, arranging inspection and obtaining safety certificate from the Electrical Inspectorate

xxii. Submission of wiring diagram, operation, maintenance and installation manuals, Test

Certificates, Technical Leaflets etc.,

xxiii. The offer shall include necessary start up spares, fuel and lube oil required for commissioning and trial running of sets until handover.

xxiv. Generator Neutral Isolator Panel with Neutral Grounding Resistor connected to earth pit (S) through separate cables.

xxv. Laying of 11KV 3C Ar Aluminium XLPE Cable from Generator to the incoming terminal of the 11KV HT VCB DG Control Panel and to the NIS/NGR Panel.

xxvi. Terminal box on Generator AMF / Control panel, generator, 11KV VCB Panel & PLC panel with inter connections through control, instrument cables,

xxvii. Terminal box for SCADA interface (cabling to SCADA by other agencies)

xxviii. PLC panel (Separate or part of relay – metering panel) with auxiliary connections through control / instrument cables to Generator/Engine, 11KV VCB Panel, to have auto load dependent start-stop arrangement.

xxix. Battery with charger,

xxx. Incoming pipes flanges from underground storage tank to intermediate tank.

xxxi. Protection earthing grid with connections to earth pits and to the body of generator/Engine, DG Aux switchgear, DCDB, PB stations etc.,

xxxii. DG Aux switchgear incoming terminals, outgoing terminals connected to fans, pump motors through power cables/control cables as applicable.

xxxiii. Emission Testing at site need to conducted during the Load Test by Approved Labs

3. Services

a) Obtaining approval of local CEIG with regards to layout, clearances and earthing drawings and permission for energizing the DG Sets.

b) After installation, exhaust gas sample shall be collected and tested in a laboratory to see the conformance with the emission norms laid by PCB for this engine rating. Necessary data shall be furnished to the customer and / or their agency who are liasioning with PCB for clearance.

c) Required parameters for foundation to be provided by the DG vendor. Erection, testing and commissioning of the DG sets including all items covered under the scope of supply.

d) Load test at site on each set shall be for a minimum period of four (2Hrs.30mins). Fuel oil and all other consumable required for the test shall be supplied by the Contractor.

e) Cleaning debris and scraps from DG premises equipment and auxiliaries on completion of the entire installation.

f) Minor touchup painting of the equipment under reference.

4. Site Conditions

Reference Design ambient or Electrical equipment	15 degree C to 30 deg C
Attitude	900 above MSL
Relative Humidity	55 to 85 %
Design Humidity	100%
Environment	Moderate conditions.
Installation	DG sets indoor

5. Requirements of Diesel Generator Units

a) General

i. Standard Diesel Engine Alternator sets and auxiliary equipments are as indicated in the product information published by the Manufacturer. Engine Alternator sets shall be suitable for parallel operation in conjunction with paralleling switchgear provided by others.

ii. The engine power (KW) shall be sufficient to deliver full rated generator set KVA, when operated at rated rpm, equipped with all engine-mounted parasitic and external loads and operated at specified site conditions. The D.G.Set need to be for Prime Power operation as per IS3046.

iii. Engine Alternator sets shall meet IEEE emergency power requirement to start and be on line within 15 seconds of to feed the distribution loads.

iv. The Engine Alternator sets shall be assembled on a robust base by the Engine Alternator manufacturer. In addition, the supplier shall provide dimensions of a concrete foundation block to match the generator set base, sized to dampen effects of disturbing vibrating forces. The foundation shall be isolated from the building structure. The generator set base shall be designed and built by the Engine Alternator manufacturer to resist deflection, maintain alignment, and minimize resonant linear vibration.

v. Vibration isolators shall be of resilient rubber design and installed between the Engine Alternator set base and the mounting surface. The isolators shall bolt to the Engine Alternator set base and foundation block. The pads shall be resistant to heat and aging, and antifreeze, diesel fuel, and cleaning compounds.

vi. The Engine Alternator sets transient response shall conform to IEEE requirements.

b) Design Of Construction Requirements

i. Diesel generator sets shall be designed without harmful vibration stresses specially, during acceleration and deceleration.

ii. Harmful tensional vibration stresses shall not occur within the range 10% above to 10% below rated idle speed and from 15% above to 10% below rated synchronous speed.

iii. Moving parts shall be designed to withstand, without damage, 115% of the rated synchronous speed. However, the generator, exciter and flywheel shall be designed to withstand over sped of 25% without damage.

iv. DG Sets shall be able to withstand all stresses imposed during normal operation, testing and overload.

v. Equipment shall be designed and manufactured to withstand damage during transit, storage at site and after installation under the specified conditions.

vi. All dimensions shall be in mm. All nuts, studs and bolts shall be designed and fabricated to metric units.

vii. Nuts shall be hexagonal and bolt holes shall be spot faced for nuts.

viii. Materials shall be as per specifications and shall be new and first class in all respects.

ix. Castings and forgings shall conform to their respective material specifications and shall be free from flaws, machined true and a workman like manner.

x. Identical parts shall be interchangeable.

xi. The design shall provide for ease of access during inspection, maintenance, and repairs.

xii. Fuel oil and lube oil piping shall be located as far as possible away from engine exhaust lines. Pressurized lines shall be installed in such a way that damage to neighbouring equipment is prevented in the event of pipe break and pipe whip.

xiii. Materials for expansion bellows on exhaust and pressurized combustion air cooler and engine, silencer and exhaust pipe down streamside of silencer shall be of suitable grade stainless steel.

xiv. The coupling between engine and alternator may be rigid of flexible as required.

xv. Simplex filters with bypass filter for servicing shall be provided in lube oil circuits.

c) Base

The DG units shall be mounted on a rigid fabricated steel sub – caste. Latitudinal beams shall be rigidly cross braced to avoid warping or bucking in transit or installation and the complete assembly shall be machined and drilled where necessary.

Anti-vibration mounding of an approved make shall be provided to absorb and damp out vibrations, which would otherwise be transmitted to the foundation and nearby structures.

d) Tools

A set general maintenance Basic tools shall be furnished for each DG set.

e) PIPING (As Applicable)

Piping for cooling water, oil etc, shall be designed fabricated and tested in accordance with IS / ISO pressure piping code.

All terminal connections and all pipe joints shall as far as possible be of welded constructions, screwed terminal connection shall be avoided.

Piping design and installation shall be suitable for periodic testing.

f) Protection During Shipment

Materials shall be handled and stored so that they are protected against corrosion, damage or ingress of foreign matter.

Flanges, openings, nozzles and terminals shall be thoroughly cleaned and adequately protected to prevent entry of extraneous material during transit and storage. Parts shall be suitably marked to facilitate matching during erection.

g) Painting

Machined and finished surfaces shall be protected against formation of trust and corrosion by application of a rust inhibitor.

All steel surfaces which are to be painted shall be thoroughly cleaned, degreased and given one shop coat of premier, prior to assembly.

All castings shall be sand blasted, degreased and cleaned before painting. Primary and final painting for work done at factory and site should be done by Contractor.

h) Inspection

The Contractor shall have rigid inspection procedure laid down to ensure quality of workmanship, compliance with material specifications and drawings, mechanical accuracy of components, identity and acceptability of all terminal, parts and equipment, both in his and his sub-Contractor works.

6. Technical Requirements of The Diesel Engine and Auxiliary System

DIESEL ENGINE

a) The diesel engine shall be four-stroke, single acting, mechanical injection type and shall furnished with at least the minimum equipment according to BS 5514 / ISO standard practices. The horsepower rating, required auxiliaries, guarantees of fuel consumption, parallel operation, governor characteristics and performance, torsional vibration and materials and workmanship shall be in accordance with BS 5514 / ISO standard practices.

b) The engine shall be equipped with a flywheel. The engine shall be provided with an exhaust gas turbo-charge with after – cooler and an integral air filter and silencer.

c) DESIGN AND CONSTRUCTION REQUIREMENTS OF DIESEL ENGINE

i. BED PLATE

Bedplates shall be of alloy cast iron or fabricated steel. In the case of steel bed plates, welding shall be done in a continuous process. The fabrication shall be stress relieved after

welding.

ii. CRANK CASE

Crankcase shall be of alloy iron casting with integral transverse diaphragm or alternatively of fabricated steel construction provided with heavy steel inner side plates to form water compartments around the cylinders. Access to bearings, camshaft, governor drive and water jackets shall be provided in the webs, journals and bearings to carry lubricating oil under pressure to the main connecting rod bearings.

iii. MAIN AND BIG END BEARINGS

Main and big end bearings shall be detachable prefinished sheets with high-grade bearing materials and shall be easily fitted without scraping or hand fitting. The big end dimensions shall be such that the connecting rods can be withdrawn through the cylinder liners.

iv. BALANCING GEAR

Engine shall be inherently balanced. Where this is not possible, engine shall be fitted with a balancing system driven from the crankshaft.

v. CONNECTING RODS

Connecting rods shall be I beam sections of high grade drop forged steel and shall carry the big end bearings.

vi. CONNECTING LINERS

The cylinder liners shall be of the separately inserted ‘ Wet ‘ type cast in alloy iron and specially machined in their bores to give an oil retaining surface. They shall be flanged at their up ends and secured by the cylinder heads, with the lower ends located and sealed in the crank case by rings of synthetic materials resisting oil, water and heat.

vii. PISTONS

Piston shall be forged aluminum alloy or cast-iron alloy and machined on their outer surface to a system o graduated cold clearance to provide good heat transfer qualities and maximum bearings surfaces consistent with clearances. The pistons shall be fitted with compression rings and oil scraper rings of hardened cast iron alloy.

viii. CYLINDER HEAD AND VALVE GEAR

The valve operating gear assembly shall be oil lubricated and shall be oil totally enclosed in alloy iron castings bolted to the crank case with narrow joint washer interposed between the head and top of liner to provide a gas tight seal. Each cylinder head shall have inlet and exhaust valves of heat-resistant steel, which seat on wear – resistant inserts. Each cylinder head shall also be fitted with a fuel injector, combined pressure relief and compression release device, if required. the combustion chamber roof part walls and fuel injector sleeves shall e accessible for cleaning purpose. Each valve shall be loaded by concentric coil springs and shall operate in long detachable valve guides.

The valves shall be operated from the camshafts one for each bank of cylinders, by roller tipped cam followers. The valve gear mechanism shall be enclosed by light detachable covers.

ix. CAMSHAFT

The camshafts, one for each bank of cylinders, shall be build up in replaceable sections of heat-treated precision- machined steel with Chromium plating and jointed by muff-couplings, the outer diameters of each rotate in gun-metal. Bushes housed in the crank case casting. All cams shall have hardened profiles. Inlet and exhaust cams shall be in one piece and keyed to the soft. Fuel injection cams of the split removable type shall be down loaded in angler location.

x. CAMSHAFT DRIVE

The camshaft may be either chain or fear driven. Gears shall employ in the “hunting tooth” principle to ensure even wear. In the case of chain drives chain tensioning gear shall be located so that it is readily accessible.

xi. FLY WHEEL

The fly wheel shall be of mild steel statically balanced after machining and shall have graduated markings around its periphery to facilitate checking of valve and fuel pump timing. Flywheel shall have sufficient mass and inertia to meet specified limits of variation of generator eliminates torsional vibration within the operating speed limits of the governor and over speed trip, barring slots shall be provided around the flywheel rim of hand barring.

xii. EXHAUST MANIFOLDS

Exhaust manifolds may be single/double branch type insulated design utilizing Ni-resist Casting to guard against high temperature growth and cracking.

xiii. FUEL OIL SYSTEMS

Fuel oil will be stored outdoors in bulk oil storage tanks provided by the purchaser. The purchaser will provide pipe connections from the tank to the fuel-oil day tank.

The supplier shall provide a 990L day tank, fabricated out of sheet steel, for each DG sets. The day tank shall be situated outside a DG room on a suitable concrete Structure to be provided by the purchaser. The day tank shall be provided with necessary level controls to operate the alarm indications.

An engine driven pump shall be provided to deliver the fuel oil from the supply line through strainers containing closely oven filtering material to the injectors.

The supplier shall provide all necessary piping, fitting, supports, valves and accessories to complete the fuel oil system.

Each Day tank shall be provided with two [2] nos. level alarm switches for: -

High level (900 ltr) / Low level corresponding to 30 mts fuel capacity of tank or 150 ltr.

Each tank shall be provided with a calibrated transparent tube for indicating the fuel level. Each tank shall be provided with a manhole, vent and drain nozzles, over flow pipe. Details of nozzles and also their orientation shall be furnished. All pipes shall be connected through flanged joints.

xiv. FUEL OIL PIPING ROUTING

Fuel oil piping routing inside the DG room shall be shown by the supplier. A single line diagram of the piping showing sizes of pipes, valves, etc., shall be furnished with the tender.

xv. LUBRICATING OIL SYSTEM

Automatic pressure lubrication shall be provided by a gear type pump at the free end of the engine and driven from the crankshaft. Pressure switches shall be provided to give alarm if the pressure falls below a set value and subsequently trip the unit when the minimum safe pressure limit is reached. A dipstick shall be provided for level measurement. All necessary accessories such as pressure gauges, temperature indicators, pressure relief valves, by pass valves, pressure switches for alarm and controls shall be provided by the supplier together with all interconnecting piping, fitting supports, valves etc.

xvi. ENGINE STARTING SYSTEM

Starting of the diesel engine shall be by electrical means. The diesel engine shall be provided with adequately rated battery of the lead acid type complete with all accessories, stand, interconnection etc.

xvii. AIR INTAKE AND EXHAUST SYSTEM

The supplier shall provide an air filter and residential type silencer with the turbo charger.

Air will be taken from the diesel room as started elsewhere in this tender.

The exhaust system shall consist of an exhaust gas driven turbo charger with lagged piping interconnecting cylinder head outlets with turbo charger inlets. Exhaust manifold shall be of fabricated steel and it shall be suitably lagged. Exhaust gas from turbo charger shall be led out through necessary pipes, adopters etc., to an exhaust gas silencer.

Expansion joints shall be provided to take care of thermal deformations. Pressure drop in the exhausts piping including silencer, bends, expansion joints etc., shall be compatible with exhaust gas leaving the engine. The exhaust piping shall be duty throughout the length from the engine outlet up to the outlet point inside the room with high temperature resistant thermal wool, with chicken mesh and on top lagged with aluminium sheet wrapping. Bending radius of bends shall be not less than 3 internal diameters of chosen piping. A drain plug shall be fitted at the lowest point for condensate extraction. Exhaust pipe shall be raised above the highest point of the building and shall meet the regulations of pollution control board. Suitable supports shall be provided for proper installation of exhaust pipe.

The silencer shall be mounted so that its weight is not supported by the engine. Exhaust pipe size shall be sufficient to ensure that the exhaust back pressure does not exceed the maximum limitations specified by the engine / generator set manufacturer. Piping size shall not be less than 10" dia with B Class MS pipes duly supported.

The muffler and all indoor exhaust piping shall include lagging to maintain a surface temperature not exceeding 65 Deg; C. The insulation shall be installed so that it does not interfere with the functioning of the flexible exhaust fitting.

Engineering data sheets detailing silencer attenuation, construction materials and all relevant physical dimensions in detail shall be provided. Data shall include bends, necessary adapters, tail pipe, brackets, supports, joints, bolts, diameter of exhausting piping, size of thimbles for penetrating walls, type of insulation for silencer, etc.

Exhaust system shall consist of the following:

- Exhaust pipe & Bends: Class 'B' M S pipe,
- Special exhaust silencer insertion loss value 25 dB (A),
- Freestanding chimney as per the specifications.

d) GOVERNING SYSTEM

The digital governing system shall conform to accuracy class A1 as per BS 5514: Part 4. In addition, when a 93KW motor for 2000KVA having a starting current of 3 Full load current (FLC) is started, the frequency dip and recovery time shall not be more than 5% and 3 Secs respectively.

Governor shall have the following features.

i. It shall be capable of operating both as an 'isochronous' or a 'speed droop' governor. The speed parallel operation shall be adjustable from 0-5% of the engine.

ii. The governor system shall be provided with electronic devices, which would sense change in generator kW load and initiate corresponding change in governor setting prior to a signal being received from normal speed governing.

iii. Governor shall be suitable for operation without external source of power supply.

iv. A KW load sensing facility shall be available in the engine governor / controller. A over speed trip shall be provided to automatically shut off fuel in case the set reaches 110% rated speed.

v. An engine mounted emergency stop push button shall be provided.

vi. REQUIREMENT OF SPEED GOVERNOR

Speed governor shall have steady state transient response and recovery times fully conforming to class A1 governors as per BS 5514 part-IV.

vii. MOTORS FOR AUXILIARY SYSTEMS

Motors if any for the auxiliary systems shall be suitable for 3 Phase, 415 +/- 10%, 50Hz +/-3% AC supply. Motors shall comply with the requirements of BS 4999 and BS 5000 for power station auxiliary duty. Degree of protection of motors shall conform to IP 55.

e) REQUIREMENTS OF GENERATOR AND EXCITATION SYSTEM

i. SCOPE

This specification generally describes the generators and associated equipment, excitation system and voltage regulator.

ii. STANDARDS APPLICABLE

The Equipment and accessories covered by this specification shall be designed, Manufactured and tested incompliance with the following latest relevant standards in order that specific aspects under working conditions are taken care of:

1. a. IEC Publication No.34-1	: Recommendations for rotating electrical machines.
b. IEC Publication No.34-1A	: Supplement to publication No.34-1
British Standard 4999	: Specification and general requirements for rotating electrical machinery.
Indian Standard 4722:1968	: Rotating electrical machinery
IEEE: 115	: Test Procedure for synchronous machines.
IS 4691 / 1968	: Degrees of protection.

The equipment and accessories for which Indian standards are not available shall be designed, manufactured and tested in accordance with the latest standards published by other recognized national standards institution.

The equipment shall also conform to the latest Indian Electricity Rules as regards safety, earthing and other essential provisions specified there in for installation and operation of electrical plants.

iii. GENERATOR SPECIFICATIONS

The alternator shall be continuously rated, three phase. Three wire, rotating field, self-excited, brush-less type alternating current machine, direct coupled to the diesel engine prime mover. The whole unit shall be designed and constructed to operate as one unit. Mechanical degree of protection of alternator shall conform to IP-22.

The diesel engine and alternator shall be mounted on a common steel base frame for grouting into or floating on a concrete foundation for fitting to embedded steel channels. Coupling shall be provided with coupling guards.

The deviation factor of the open circuit line-to-line terminal voltage of the alternator shall not exceed 0.1.

Alternator shall be capable of withstanding, without damage a 30 second three phase short circuit at its terminals when operating at rated KVA and power factor at 5% over voltage, with fixed excitation.

Alternator shall be capable of carrying a one-minute overload of 50% of normal rated current with the field set for normal rated load excitation.

Alternator shall be designed to be capable of operating in parallel with other DG sets of similar rating and / or grid.

Alternator winding shall be insulated with class F insulation. The machine shall be naturally ventilated. 3 wire type embedded temperature detectors for winding and bearing shall be provided.

Alternator shall have amply dimensioned terminal boxes for easy termination of aluminium power cables to terminate leads from space heaters; windings and bearing temperature detectors; to accommodate protection CTs.

Terminal box shall be suitable for cable entry from top bottom or sides.

iv. GENERATOR REACTANCE:

Sub-transient reactance shall be low to maintain fault contribution from the generation within permissible limits. The transient reactance should be as low as possible consistent with the need to limit voltage drop on sudden application of load.

f) Generator Construction

i. GENERAL

All parts of the generator and accessories shall be capable of withstanding electrical, mechanical, thermal and other stresses experienced in operation and during short consistent with the need to limit voltage drop on sudden application of load.

Spacer blocks and wedges used in the construction of stator windings shall be made of non-shrinkable material. Binding of coils shall be non-continuous, preferable using glass cord or equivalent. Generator stator and field windings shall be insulated with class F insulation. Core plate insulation shall also be class F. All armature winding connections shall be brazed strand to strand to provide maximum margin against local overheating.

ii. BEARING INSULATION

Insulation shall be provided to break the paths of stray current at two places in series with provision made for determining the insulation resistance each insulation piece. The insulation under the bearing pads shall be made of non-hygroscopic material.

iii. STATOR FRAME

Stator frame shall be of one-piece construction, fabricated from heavy steel pipe and designed for minimum noise and vibration.

All stationary parts of the generator shall be designed to avoid resonance at 50Hz, 100Hz and 200Hz.

Generator shall be designed with B3 construction i.e., with two end shields and foot mounted.

iv. ROTOR

Rotor shall be properly balanced at rated speed, critical speeds over speeds.

v. VENTILATION

Generator shall be air cooled with shaft mounted fan.

Shaft mounted fans shall be provided to effect air circulation through the ventilation system.

vi. CONNECTION

The 3 phase windings of the generator shall be arranged for star connection and shall be suitable for operation with the neutral grounded.

vii. STATOR **TERMINALS** AND TERMINAL ARRANGEMENT

The two terminals of each phase winding shall be brought out of the generator frame at approved locations. Terminal markings shall be in accordance with BS 622. The direction of rotation shall be marked on the suit purchaser's cables/ bus ducts and enclosed to safeguard against short-circuits by rodents etc., Suitable cable glands or cable sealing boxes as specified shall be provided on the enclosure to facilitate entry of the cables.

viii. TERMINALS

The lines and neutral ends of each phase winding of the generator shall be brought out two separate terminal boxes. The line end terminal box shall be phase segregated for HV machines and phase insulated for LV machines. Terminals boxes shall have facilities for mounting CTs specification on 6 suitable located terminals.

Cables sizes shall be as indicated in the Generator Data Sheet enclosed, if applicable.

Fault withstand capability of the terminal box shall be 21 KA for 1 Sec.

ix. CURRENT TRANSFORMERS

Current transformers, two per phase shall be provided at the neutral end of the generator with rating as in Generator Data Sheet for over current, differential and restricted earth fault protection.

Offer for current transformers shall be accompanied by Ratio and phase angle errors and complete error for protection class CTs

Magnetization characteristics extending at least up to 150% of the excitation current at knee point voltage for both class PS and protection CTs.

Current transformers shall have terminal blocks with facility for short circuiting grounding the secondary.

x. TEMPERATURE DETECTORS

A minimum of two platinum resistance type temperature detectors shall be provided per phase of the generator, between the coils of the stator windings and two on bearings. The resistance value of the RTDs shall be 100 ohms at 0 deg C. The supplier may provide additional RTDs for measuring temperatures at specific points in the machine. In addition to RTD, supplier may provide additional monitoring equipment if required to monitor equipment condition.

Temperature detectors of resistance type shall be provided, in accordance with America Standard SpecificationC.50-1. One RTD shall be embedded in each bearing.

The detectors shall be installed at locations where the highest temperatures may be expected. The leads of the temperature detectors shall be brought in a neat and adequate manner to an easily accessible terminal box on the generator frame. The minimum size of the leads shall be 1.5 Sq.mm. The leads shall be protected against stray electrical fields mechanical damage.

The temperature detectors with their leads shall be accurately calibrated. Test reports giving results of the calibrations shall be submitted for purchaser's scrutiny.

A drawing indicating locations of the detectors shall be furnished.

xi. SPACE HEATERS

Space heaters of adequate capacity rated for 240V, 50Hz single phase service shall be provided for the generator, exciter, and associated cubicles to maintain inside temperature sufficiently above outside ambient so that condensation o atmospheric moisture is prevented when the equipment is not in service.

The heaters shall be mounted in an accessible location. In the case of the machines, they shall be located in the lower part. Terminals of the space heaters shall be brought out to a separate terminals box.

KW rating of the space heater shall be indicated.

g) EXCITATION SYSTEM

i. BRUSH LESS EXCITATION SYSTEM

a. The brush less excitation system shall have the following provisions: -

b. A revolving armature AC exciter directly coupled to the generator rotor at the outboard end shall be provided. The output of the AC exciter shall be rectified by the rotating diodes connected as a 3-phase bridge.

c. The rotating rectifier components shall be contained against centrifugal forces by adequately designed retaining ring. The rectifier design shall be based on one high power diode and fuse per parallel path. Suitably rated heat sinks which will also act as a fan shall

be provided for each diode.

d. DC outgoing poles shall preferably be segregated by locating Rectifier Bridge on either side of the shaft. Each arm of the bridge shall be made of more than one high power diode arm arrangement in a suitable configuration to ensure that the cells withstand all fault conditions to which they may be subjected.

e. The total number of diode arms shall be such that failure of up to 25% diode arms will not cause restrictions on the unit operation at its rated condition, including field forcing. Suitably rated varistors etc.., shall be provided to give a path for the reverse polarity induced currents resulting from the generator pull-out, power swing and any other abnormal conditions. Diodes and associated protective devices shall be mounted radially. It shall be ensured that the rectifying junctions are held in compression under speed.

f. Excitation system shall have thermal capability equal to or better than the field of requirement of the generator, when operating at rated KVA and at any voltage between 5% below and 5% above rated voltage.

g. Exciter rated voltage shall be at least 110% of the rated machine excited voltage. Exciter ceiling voltage shall not be less than 130% of the exciter rated voltage.

h. Insulation of exciter shall be class F.

ii. VOLTAGE REGULATOR

a. The voltage regulator shall be automatic, high speed, non- band type with provision for current compounding. The voltage regulating system shall be suitable for automatic control of voltage.

b. Steady state accuracy of the voltage regulator from non-load to rated load shall be within +/-2.5% of rated generator voltage of any one phase at any p.f between 1.0 and 0.8 lagging from cold to hot variations.

c. The voltage regulator shall be capable of supplying excitation current in the event of a 3-phase short circuit at the generator terminals to facilitate operation of the protective devices and under all conditions of loading specified.

d. Alternator shall have a reliable 3 phase voltage sensing compound excitation system having:

e. Capability to build-up the voltage from residual magnetism.

f. Protection against low-speed operation.

g. Voltage / hertz responsive feature.

h. Provision to manually adjust the alternator voltage within +/- 5%

iii. GROUNDING

A non-corrodible metal pad shall be welded or brazed at two different locations on the frame and shall have a threaded hold at the center for connecting the cable lugs by means of hexagonal head bolts and spring washers.

Two independent grounding points shall be provided on opposite sides near the bottom.

Grounding points shall be suitable for the following grounding strip.

- Machine : 50 X 6mm Cu. Flat
- Power Panels : 25 X 6mm Cu. Flat
- Control Panels : 25 X 3mm Cu. Flat

h) Performance Requirement of the Diesel Generator Units

i. The DG sets and the associated auxiliary system shall be designed to provide a standby source of power of a high reliability.

ii. The DG set shall be capable of starting from cold condition and reaching synchronous

speed and ready to take load in a period of ten (10) seconds from the initiation of start impulses without suffering undue stress, wear and tear. The DG sets shall be capable of accepting the maximum rated load of the generator within a period of thirty (30) seconds from the initiation of start impulse.

iii. The DG sets shall be capable of operating at rated load on the generator

- in isolation
- in parallel with similar DG sets.

iv. Diesel generator shall be capable of delivering continuously at the terminals of the alternator 1600 kW Prime duty for 2000 KVA sets at 0.8 P.F at 11KV when the ambient surrounding the alternator is between -15 deg c to 30 deg C, intake air for combustion 30 deg C.

v. The DG sets shall be capable of peak-output of 10% in excess of the rated output for a period of one (1) hour in every 12 hours of continuous running at rated load, without exceeding permissible temperature limits and with a faintly visible exhaust.

vi. The DG sets shall be capable of meeting the specified performance when using commercially available HSD oil to as per IS: 1460-1974.

vii. The DG sets shall be capable of starting on their own when external power supply is not available

viii. Diesel generator shall maintain output accuracy of +/-1% of voltage and +/- 0.25% of frequency at the terminals of the alternator under steady state condition.

ix. During recovery from transients caused by step load increase or resulting from the disconnection of the largest single load the speed of the D.G.set shall not exceed 115% of the nominal. Further, the transient following the complete loss of load shall not cause the speed of the unit to attain the over speed set point.

x. The sub transient and transient reactance of the generator shall be chosen to meet the above requirements.

xi. The voltage and frequency of the generator shall be adjustable between + / - 5% and + / - 2.5% of the nominal values respectively from local D.G. control panel and remote-control panel.

i) Items of Guaranteed Performance

i. Following items of performance shall be guaranteed by the supplier in respect of the DG sets and auxiliaries, when operating under specified site conditions.

ii. Net electrical power output at specified power factor and terminal voltage under specified conditions considering de-rating factors as given in ISO standards.

- Fuel oil consumption at full load.
- Lubricating oil consumption at full load.
- Jacket water temperature to and from engine. (As applicable)
- Lubricating oil temperature to and from engine.
- 10% overload for one hour in every 12 hours of continuous running at rated load.
- Generator efficiency at ½, ¾ and full load at specified power factor and terminal voltage.
- Governor response and over speed capability.
- Voltage regulator response.
- Contractor shall indicate the tolerance applicable to each of the guaranteed parameters above and the reference standard.

j) DIESEL ENGINE DRIVEN GENERATOR

The engine/generator sets shall meet the following parameters:

- A governed speed of 1500 rpm.
- Rated 0.8-power factor for prime operation.
- To operate at 11000 Volts, 3 phase, 3 wires, 50 Hz at 5000 meters elevation above sea level.
- Temperature range of 15 Deg; C to 35 Deg C.
- Equip generator with a liquid cooled diesel engine.
- Engine-mounted radiator
- Alternators shall be of reputed make, salient pole, brush less, synchronous, revolving field, air-cooled and drip-proof and OPEN DELTA connected with a separately excited system using a permanent magnet generator.
- The alternators shall be capable of withstanding, without adverse effects. Over-speeds of 25 percent above the governed speed for the duration of one minute.
- Generators shall have the capability to provide minimum of 300 percent of rated three-phase current for 10 seconds.
- Engine mounted fuel filter.
- Phase segregated terminal box shall be provided which shall be suitable for terminating 11KV 3C Ar Al. XLPE, earthed type cable. The neutral terminal shall be brought out in a separate terminal box on the opposite end.
- THD at no load shall be < 3%
- 3 Nos. single phase 11 kV / 110 V /√3 PTS shall be supplied for AVR sensing.
- Exhaust System – Exhaust system shall be connected to a freestanding chimney. The chimney shall be suitable for connecting all Generators.

k) Requirements of 2000 KVA, 11 KV D.G. Set.

i. DIESEL ENGINE:

Diesel Engine, Radiator Cooled, Turbo charged, with After Cooler, suitable for Generating Set applications, developing 2319 BHP for 2000 KVA DG SET @1500 RPM under NTP conditions of BS:5514, with an overload capacity of 10% for one hour, in any 12 continuous hours operation. The Engine is equipped with the following standard accessories as per the specification given in this Tender.

ii. COOLING SYSTEM

Consists of Radiator with Fan, Engine Mounted Water Pump, Thermostat, Corrosion Inhibitor Coolant and Self Control piping.

iii. FUEL SYSTEM

Consists of PT fuel pump, Injectors, Fuel Filters and Self-Contained piping.

iv. LUBRICATING SYSTEM

Consists of Oil Pump, Strainer Lube Oil Cooler, Oil Filter, Bypass Filter and Self-Contained piping.

v. AIR INTAKE SYSTEM

Consists of Dry Type Filter, Air Cleaner Manifold with necessary connections and turbocharger with after cooler

vi. EXHAUST SYSTEM

Consists of Exhaust Manifold, Flexible and Residential Silencer.

vii. GOVERNING SYSTEM

Digital Governor Controller.

viii. STARTING SYSTEM

24V D.C. Starter Motor, Battery Charging Alternator with in-built regulator.

ix. DG CONTROLLER PANEL (Near the DG set) Consists of the following parameters with Digital indication.

a. Water Temperature.

b. Lube Oil Pressure.

c. Engine RPM.

o Running Hours.

o Fault code display

o Emergency push button

o Auto – Manual selector

Other feather touch switches:

x. In the Relay metering Panel

a. Battery Voltage.

b. Voltage between phases

c. Current in each phase

d. Power Factor

e. KWhr

f. Battery charger failure.

xi. Trip Indication LED Red Display for

a. High Water Temperature.

b. Engine Over Speed.

c. Low Lube oil pressure.

d. Low Coolant Water Level.

e. Battery charger failure.

f. Sensor Fault.

xii. Accessories

a. Flywheel Housing.

b. Flexible Coupling.

c. Coupling guard.

xiii. ALTERNATOR

Standard design Alternator rated at 1600 KW for 2000 KVA DG SET at 0.8 PF, 11 KV, 3Phase, 3 wires, 1500 RPM, 50 Hz. Brush less design in screen protected, drip proof, IP :22 enclosure with WTD & BTDs, Space Heater Insulation Class “F” Band of Voltage Regulation +/- 2.5% of rated voltage from no load to full load. The Alternator generally conforms to BS: 2613/5000.

xiv. BASE FRAME

Sturdy, Fabricated, Welded construction, Channel Iron Base Frame for mounting the above Diesel Engine and Alternator.

xv. FUEL TANK

990 Liters capacity Fuel Tank for ONE each DF with supporting stands complete with level indicator, fuel inlet and outlet, air vent, drain plug, inlet arrangement for direct filling and

set of 5 ft. long fuel hoses.

xvi. BATTERIES:

Set of 4-Nos. 12 Volts, 27 Plates, Dry Uncharged Batteries.

xvii. ANTI VIBRATION MOUNTS:

Set of Anti Vibration Mounting Pads.

GENERATOR DATA SHEET	
Rated frequency	:50 Hz
Number of phases	:3
Winding Connections	: Wye
Generator continuous outputs rating	:1600 KW (2000 KVA)
Rated Voltage of Generator	:11000V
Power factor	:0.8 lag
Over load capacity for one (1) h in every 12 h of continuous running at rated load	:10%
Type of insulation a. Armature winding b. Field winding Connections Core Insulation	 : Suitable for 11000V : Suitable for 11000V : Suitable for 11000V : Suitable for 11000V
Temperature rise at max. Continuous Rating over 40 deg C a. Armature winding (by resistance) b. Field winding (by resistance) c. Core and mechanical parts in contact with adjacent insulation (by thermometer)	Temperature rises as per standards : 100 Deg C : 100 Deg C : 80 Deg C
Type of enclosure	Screen protected drip-proof IP22
Permissible voltage variation of voltage for satisfactory operation at rated KVA, rated Speed and rated power factor	+/-1.5%
Excitation system	Brush less type rotating armature, stationary.
Voltage regulator a. Voltage setting range of the regulator voltage. b. Steady state accuracy of voltage c. Quadrature droop circuit provided limit the reactive KVA	 + / - 5% of rated Less than + /- 0.5 of regulator from no-load to rated generator voltage full load : Yes
Maximum period to recover the Generator voltage to the set value for a step application or rejection of rated power factor.	: 0.5 sec

I) TECHNICAL SPECIFICATION FOR NEUTRAL ISOLATOR WITH NEUTRAL GROUNDING RESISTOR PANEL

i. SCOPE

This specification generally describes the neutral isolator and neutral grounding resistor panel and

associated accessories.

ii. STANDARDS APPLICABLE

The Equipment and accessories covered by this specification shall be designed, Manufactured and tested incompliance with the following latest relevant standards in order that specific aspects under working conditions are taken care of:

IEEE-32 for Resistance rating & temp is concerned IS-2147 for the type of enclosure.

iii. GENERAL CONSTRUCTION

a. Free standing, Floor mounting, Indoor type, Panel fabricated out of CRCA sheet of 2mm thick with suitable reinforcements and with louvered sheets provided on outside and covered with fine mesh to make the unit vermin proof.

b. 11 kV, 100A, vacuum contactors shall be used for the D.G. Set Neutral Isolation. The Neutral Grounding resistors shall be provided in the neutral earthing conductor to limit the fault current to 100A in the event of a line to ground fault.

c. The resistance shall be of Punched stainless steel material and rated 100A for 10 sec with resistor value of 63.5 ohms.

d. The top of the resistor portion will have a perforated sheet of 2.1mm hole to let out the heat dissipated by the NGR during fault conditions.

e. The paint finish shall be of Siemens gray as per shade RAL – 7032 both inside and outside.

f. Foundation holes will be provided in the bottom channel base of the unit for grouting the panel to foundation. The cable entry can be either from Top of Bottom through undrilled removable type Gland plates.

iv. RESISTOR BANK CONSTRUCTION

The grids will be of punched out of SS steel grade ASTM-A240-304. Grids thus will made will be assembled on to a threaded MS rods having interleaving porcelain separators as inter grid insulation. The Inter grid connection is by SS hardware. The resistance will be assembled in the form of banks and the number of banks will be stacked one above the other in the Resistance compartment.

v. REQUIREMENTS OF NGR PANEL

The panel shall comprise the following components.

a. 1 No. 11KV, SP, 400A Vacuum contactor rated suitably with aux. contacts.

b. 1 No. 11KV Epoxy Cast Resin CT, Ratio 50 / 5, 5P10, 15VA for E/F Relay.

c. 3 Nos. 11KV Epoxy Cast Resin CT, Ratio 150 / 5A, 15VA, PS class for Differential Protection.

d. 1 Set of reputed make panel Lamp, Panel Heater, and Control Fuses.

e. 1 Set of 100A Rated Aluminium Busbar.

f. Sets of Punched SS Grid Resistor unit of rating 100A, 63.5 ohms, 10 Secs with a Max.Temp.rise of 375deg C.

g. Sets of Green & Red Indicating Lights for Isolator ON / OFF.

h. Sets of CT & Control Terminals.

By using a combination of isolating devices as per the Single Line Diagram enclosed, flexibility of running the Generators in Solo & Parallel modes are possible. The remote switching of the Isolating devices may be done by using either a PLC or Contactor Logic and the scope of the same is to be included in the offer.

vi. GUARANTEED TECHNICAL PARTICULARS

(Of the Grid Offered – Punched SS)

Type of Grid	: Punched SS. ASTM-A240-304
Ohmic Value	: 63.5 ohms
Tolerance on cold ohms	: + or –7.5%
Duty Rating	:10 Secs
Rated voltage	:11 KV
Rated Current	: 100 Amps
Type of Cooling	: Natural Air
Type of enclosure	: IP-42 (Panel)
Installation	: Indoor
Interconnection	: 25 X 6 mm Copper Flat
Max.Temp.rise:	
Resistor	: 375 deg C as per IEEE-32
Enclosure	: 55 deg C as per IEEE-32
Type of protection for	: Resistor portion

vii. TESTING

The following tests shall be conducted at your works on each of the equipment and in house test certificates shall be given in duplicate for reference & records.

a. Cold Ohmic value test at room temperature (within + or – 7.5% tolerance)

b. Megger test between grids & ground by 2500V meggar.

c. High Voltage withstand test of 2.5KV for 1 minute for LT circuit.

d. High Voltage withstand test of 28KV for 1 minute for HT circuit.

m) DG POWER SYNCHRONISATION SYSTEM

i. Functional Requirement

a. DG Monitoring and Controls including Synchronization, Load sharing between the DGs.

b. Communication with the DG Electronic Governors on hard wired interface.

c. Power monitoring and Breaker status monitoring at the main incomers of the DGs

d. Accurate Power monitoring at the various down side feeder points like AC Loads, Lighting loads, Water Treatment Plant etc., This should also enable Tariff Calculation Development wise / area wise.

e. Control and individual breakers up to the block loads to enable load shedding. The load shedding scheme should be in the order of priority / criticality.

f. Integration with SCADA System to enable effective ventilation system control and load shedding.

ii. SYSTEM DESCRIPTION

a. The system shall be equipped with load demand monitoring and control to automatically program the generator sets to start, parallel and share system loads, which includes the control of all outgoing changeovers. This shall include: Power monitoring of all Generators and transformer.

b. Auto Load sharing between the generators.

c. The switchgear load sensing circuits shall monitor station load demand and determine how many generator units are to run, when they are to be started, stopped, and at what levels of loads. The system load circuits shall be kilowatt sensing from the switchgear bus and completely adjustable.

d. Adjustable time delays shall be incorporated in the pickup and drop-off load sensing circuits to avoid unnecessary starting and stopping on load surges. Load sensing circuits shall be automatically passed to the next sequenced generator unit, if any safety shutdowns occur.

e. The system shall include automatic and manual, control to fully utilize the available power.

f. At no time shall the generators be paralleled with the utility.

iii. PROGRAMMABLE LOGIC CONTROLLERS (PLC)

All required logic shall be derived using a PLC. It shall have facility for monitoring the status of the generator parameters and breakers, generating alarms, controlling the breakers and for monitoring the power at every breaker. The output relay contacts shall have adequate making and breaking capacity. All necessary transducers for inputting the data to the PLC shall be in the supplier's scope.

iv. SYNCHRONIZATION

The PCC (Power command controller) or Generator Synchronizing Module (GSM) takes Current Transformer (CT) and Potential Transformer (PT) inputs from the synchronizing bus and PT inputs from the reference bus and shall perform the following functions:

a. Synchronization.

b. Load sharing (Active & Reactive).

c. Anti motoring.

d. Power monitoring.

This feature shall facilitate the automatic synchronization of generators onto a reference bus. The PCC / GSM shall compare the synchronizing and reference bus parameters continuously. When the synchronization conditions are met, the PCC / GSM shall issue a "close breaker command" to close the breaker.

When the system reaches the required limits the PCC / GSM shall give a command to the PLC or directly to close the breaker, in turn synchronizing the Generator with the other generator sets.

v. LOAD SHARING

Apart from auto synchronization, the PCC / GSM shall have a built-in load sharing feature. Active load sharing shall be achieved by adjusting the engine speed via the governor, whereas Reactive load sharing shall be achieved by varying the AVR. These commands shall be generated by the PLC / PCC and the outputs given shall be potential free contacts.

vi. POWER MONITORING

In addition to the synchronization function, the PCC / GSM shall provide extensive array of monitoring information for systems wired in Wye Delta or open delta. The PCC / GSM shall monitor different electrical parameters of the synchronizing bus and parameters of the Reference bus.

vii. COMMUNICATION WITH GOVERNOR

The interface with the generator governors shall be of a format suitable for effective communication with the electronic governor fitted to the generators.

The interface shall be able to:

(a) Effectively raise and lower the speed of the engine.

(b) Provide all the engine related data including diagnostics and Alarm information from the engine.

n) TECHNICAL SPECIFICATION FOR RELAY, MONITORING AND ANNUNCIATION PANEL.

i. SCOPE

This section describes the requirement of control, instrumentation and protection for the diesel generator sets.

ii. CODES AND STANDARDS

The design, manufacturing and performance of equipment shall comply with all currently applicable standards, regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the vendor of his responsibility.

Unless otherwise specified, equipment shall conform to the latest applicable Indian or IEC Standards. The Indian Standards is IS : 8623.

iii. CONTROL AND ACCESSORY EQUIPMENT

110V DC will be provided by the purchaser. If voltage other than 110V DC is required by the supplier, necessary arrangement shall be made by the supplier, necessary arrangement shall be made by the supplier, within the cubicle, to obtain the necessary voltage/s by providing transformers, inverter / Converter etc.

Control supply shall be controlled within the cabinet by adequately rated heavy duty, load break isolator / switch, HRC fuses, MCB etc., as the case may be.

iv. AUXILIARY CONTACTOR FOR BATTERY CHARGER.

A suitable auxiliary Contractor shall be provided for connection the battery charger to the main supply. A contactor shall be provided with an isolating switch and shall be so arranged as to disconnect the battery charger during engine starting.

v. FUSES

All fuses shall be of HRC cartridge conforming to IS : 2208 mounted on plug in type fuse bases having a prospective current rating of not less than 80 kA. Fuses shall be provided with visible operation indictors to show that they have operated. All accessible live connections shall be adequately shrouded, and it shall be possible to change fuses with the circuit live, without danger of contact with live metal. Insulated fuse pulling handle shall be supplied with each control cabinet.

vi. INSTRUMENTAL TRANSFORMERS

Current and Voltage transformers shall conform to the requirements o IS : 2705 and IS : 3156 respectively. Unless otherwise specified it shall be the responsibility of the vendor to ensure that the class and VA burdens of instrument transformers provided are adequate for the meters and relays connected to them. Facilities shall be provided to short circuit and ground the CT secondary in the CT secondary leads to carry out current and ground the CT secondary in the CT secondary leads to carryout current and phase angle measurements with CTs in service. Voltage transformers shall be provided with suitably rated primary and secondary fuses.

vii. CONTROL TRANSFORMERS

All AC control equipments shall be suitable for operation on 1 phase, 110V, 50Hz system. Suitable rated 415 / 110V control transformers as required shall be supplied as an integral part of the control cabinet. Each control transformer shall be complete with isolation facilities, primary and secondary HRC fuses. One end/ center point of the control transformer secondary shall be earthed.

viii. INDICATING INSTRUMENTS & METERS

Electrical indicating instruments shall be of moving iron type having 144mm square, 90 deg scale. These shall be mounted flush on the panel with only the flanges projecting. Dials shall be while

with black numbers and lettering. Parallox free dial shall be provided. Ammeters measuring upto 10A shall be directly connected, while those measuring above 10A shall be connected through CTs. Voltmeters shall be connected through suitable selector switches and protected by the indicating instruments and meters shall be 1.0

ix. RELAYS & TIMERS

All protective relays shall be of rectangular in shape, suitable for flush mounting with only the dust tight covers projecting beyond the cabinet door. Relays shall be equipped with external reset, positive action operation indicator visible from the front. Voltage relays shall have sufficient capacity for continuous energisation, using external resistors, if necessary.

Unless otherwise specified, auxiliary relays can be of fixed type mounted inside the cabinet but shall be provided with individual dust-tight covers. Auxiliary relays shall be rated to operate satisfactorily between 70% and 100% of rated voltage.

Number of relays and timers shall be as pr requirement. The relay / timer coil voltage shall be 110V DC. There shall be adequate spare contacts which shall be exclusive for the use of purchaser. All contacts on relays / timers shall be wired up to terminal blocks.

x. CONTROLS & SELECTOR SWITCHES

Control and instrument switches shall be of totally type having enclosed contacts which are accessible by removing the cover and shall be provided with properly designated escutcheon plates. Clearly marked to sloe the operating positions. Control switches shall have momentary contacts, spring return to center, with pistol- grip handle. Instruments and selector switch shall have stay-put contacts. The number of contacts and their operation in each switch shall be as per the requirements of the connected circuit.

xi. PUSH BUTTONS

All push buttons shall be to push-to actuate type having 2 NO and 2 NC self reset contacts, they shall be provided with integral escutcheon plates, engraved with their functions.

xii. INDICATING LAMPS

Indicating lamps shall be of the filament LED type having double contact bayonet caps and low watt consumption. Lamps shall be provided with series resistors.

xiii. SPACE HEATER

Strip type space heaters of adequate capacity shall be provided inside each cabinet to prevent condensation of moisture. Space heaters shall be rated for 1 ph, 240V, 50Hz supply. Heaters shall be complete with ON-OFF switches, HRC fuses in phase, link on neutral and a thermostat to control switching of the heater. Power supply shall be provided from purchaser's panel.

xiv. INTERIOR LIGHTING AND RECEPTACLES

Control cabinet shall be provided with a 1 ph, 240V, 50 Hz lighting fixture for interior illumination controlled by an ON-Off switch. In addition to the above, a 1 ph, 240V, 50Hz, 3pin receptacle shall be provided.

xv. ALARM AND SUPERVISION SYSTEM

The alarm and supervision system shall have:

a. A push button for clearing the audible alarm (visual annunciation will persist)

b. A push button for clearing the visual annunciation after the fault has been cleared.

c. A push button for testing the illuminated transparencies.

d. All alarm devices shall be suitable for operation on 110V DC.

xvi. PANEL INTERNAL WIRING

a. Control panel shall be supplied completely wired, ready for purchaser's external connections at the terminal's blocks. All wiring and cables shall be carried out with PVC insulated, stranded copper conductor wire / cables. Power circuits shall be wired with stranded copper conductors of adequately sized to suit the rated current. The minimum size shall be 4sqmm control, alarm

indication circuits shall be wired with stranded copper conductors of size not less than 1,5 Sq. mm CT circuits shall be wired with stranded copper conductor size not smaller than circuits shall be wired stranded copper conductor size not smaller than 2.5 Sq. mm

b. Power and control wiring shall be separately run and neatly bunched.

c. Wiring affected by stray electromagnetic fields shall e suitably shielded or run as twisted pairs where applicable.

d. Wiring for control switches, lamps, meters etc., mounted on doors shall be bunched together and supported in a loop in order to prevent any excess strain being applied to the wiring when the door is opened.

e. All covers both internal and external, which are removable to allow access to compartments shall be inscribed 'Danger'.

f. Engraved core identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends shall not fall off when wire is removed. Spare auxiliary contacts of all relays, contacts etc., shall be wired to terminals blocks.

g. All wiring shall be terminated on terminal blocks using solder less crimping type tinned copper lugs. Insulating sleeves shall be provided at all the wire terminations. All wiring shall be nearly bunched and cleared within the cabinet. Wiring troughs shall be provided for vertical panel wiring and for interconnecting wiring between front and fear and rear section of the cabinet.

h. One piece moulded, 650 V grade terminal blocks complete with insulated barriers, terminals studs, washers nuts and lock nuts and identification strips shall be used. Terminals for power connections shall be adequately rated for the circuit current and the rated for other terminal blocks for control etc., shall not be less than 15A. At least 20% spare terminals shall be provided. Terminal blocks for control, indicating etc., shall be suitable for connecting two conductors of purchaser's cables of following sizes: -

1.	Potential and control circuit	Two of 2.5 Sq mm stranded Copper conductor.
2.	CT Circuits	Two of 4 Sq mm or four of Sq mm stranded copper, conductors.

Terminal blocks shall be numbered for identification and grouped according to function. Terminal blocks for CT secondary loads shall be provided with short circuiting and earthing facilities. There shall e minimum clearances of 250mm between the first row of terminal blocks and the associated gland plate. Also, the clearance between the first row of terminal blocks shall be minimum of 100 mm.

xvii. EARTHING TERMINALS

Control panel shall have to separate earthing terminals suitable for necessary earthing conductors o size specified

xviii. CONTROL PANEL

a. Panel shall be cold rolled sheet steel enclosed, of thickness not less than 2.5 mm free standing, floor mounting, indoor type, dust and vermin tight, degree of protection IP – 54, with front accessibility having concealed hinged doors, with key locked and handles and bolted rear and side covers.

b. Ventilation louvers shall be at the side and /or back and shall be fitted with fine mesh screens to prevent entrance of rodents or large insects.

c. Foundation channel with nuts, bolts, spring washers, 3mm thick undrilled gland plate, cable gland shall be part of the supply.

d. Components mounted on the panel shall be flush type. Arrangement of components shall be such as t render easy accessibility for maintenance and troubleshooting.

e. Heating emitting components like resistors shall be shielded from others by fiber glass sheet separators or similar materials.

xix. MAINS OPERATED BATTERY CHARGING EQUIPMENT

a. The battery charger shall be of the static type employing semi -conductor devices, the whole being enclosed in an adequately ventilated enameled corrosion resistant sheet steel case of an approved type. This shall be part of relay & monitoring panel, mounted inside the same.

b. The charger shall be incorporated within the control panel with its associated instruments and controls mounted on the control panel. The instruments and controls shall match those of the main panel.

c. The charger shall have an illuminated indicator on the panel front to show when the charger is switched on. The charger shall be of adequate size and shall at all times monitor the battery conditions and automatically control the charging rte to suit the state of the battery, maintaining it in a properly charged condition when not in use. Following a period of use,

d. the charger shall automatically re-charge the battery in the shortest practicable time consistent with battery welfare and the size and output of the charger shall match battery size and shall at all times monitor the battery conditions the charging rate to maintain the state of the battery, maintaining it in a properly condition when not in use.

xx. PROTECTION

The diesel generator shall be tripped under the following conditions: -

a. 110V DC control supply failure.

b. Over-speed of diesel generator set

c. Low lube oil pressure

d. excitation failure.

e. Incomplete start after a present time.

f. High jacket water temperature.

g. DG differential protection.

h. Reverse power protection.

i. Earth fault protection.

j. Emergency stop.

xxi. ALARM AND INDICATIONS

Local Alarm on Panel:

The following alarms shall be included in the alarms and supervision system:

a. High jacket water temperature (As applicable)

b. Low lube oil pressure

c. Generator bearing temperature high.

d. Generator winding temperature high

e. Fuel oil day tank level low.

f. Fuel oil day tank level high.

g. 110V DC control supply failure.

h. Reverse power trip

i. Over current trip

j. DG earth fault.

k. Emergency stop.

l. Starting failure.

Local Lamp Indication on each Diesel Control Panel:

The following Meters shall be included in the Metering Chamber of the Panel

i 1 No. Ammeter with selector switch. (0 – 200A)

ii 1 No. Voltmeter with selector switch. (0 – 12KV)

iii 1 No. Frequency Meter.

iv 1 No. KW Meter

v 1 No. KVA Meter

vi 1 No. KWHr Meter

vii 1 No. P F Meter

viii 1 No. Trivector Meter

The Following Protection relays shall be included in the Relay Panel:

a. IDMT Three O/C + E/F relay with highest

b. Over / Under Voltage Relay.

c. Reverse Power Relay

d. Restricted Earth Fault Relay

e. Differential Relay

f. Auto Synchronizing Relay

g. Auto Load Sharing Relay

h. Thermal Overload

i. Over / Under Frequency

j. Loss of Field

k. PT Fuse Failure

The following Auxiliaries shall be included

a. 1 No. Multipoint Temperature Scanner for WTDs & BTDs.

b. 1 No. Motorized Potentiometer for speed / voltage, raise / low.

c. 1 Set of Indicating Lamps for Load ON DG & Load ON Mains.

d. 1 No. Emergency Push Button.

o) FREE STANDING CHIMNEY

Total Gas flow from 2 x 2000 KVA at portal: To be confirmed by vendor.

Temp – deg. C	To be confirmed by vendor
Chimney material	: IS 2062
Design code	: IS 6533
Wind Load	: as per IS 875 (Part 3)-1987
Earth Quake stability	: as per IS 1893 – 2002
Foundation to be designed	: To withstand wind load and earthquake
Painting	: Anti corrosive black painting shall be carried out on the Inner surface of the chimney. Shall confirm to IS 158 – 1968.

Note: The exhaust from the Generators shall be directly exhausted to atmosphere without any treatment. This requirement shall meet the norms of State Pollution Control Board.

p) BATTERY AND BATTERY CHARGER

i. BATTERY

Batteries – 25 Plate, 180 AH, heavy duty

Batteries shall be of lead acid type, heavy duty Automotive power mounted near the generator. A corrosion resistant battery rack shall be provided for mounting. Battery shall have sufficient capacity to provide for the engine/generator safety circuits, for 24 hours without recharging. The batteries shall be suitable for 6 successive attempts each of 10 secs duration with a gap of 5 sec forward starters. The battery bank shall be provided with steel stand and a containment tray. Also, a rubber mat shall be provided below the battery rack. Battery shall be confirming to IS: 1651.

ii. BATTERY CHARGER

a. A current limiting battery charger shall be provided to automatically recharge the batteries. Battery charger shall have boost and trickles charging features with built in voltage regulators. Battery Charger shall be suitable for operation on 230V AC, 50 Hz supply with variation of +/- 10%. The charger shall charge at 2.17 Volts per cell and float at 2.33 Volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, DC Ammeter, and fused AC input. The amperage output shall be not less than 10A. Each Generator shall be provided with separate battery charger.

b. The following indications shall be required:

Input supply on.

Battery charge/discharge current.

Output voltage.

c. Voltage free change-over contacts shall be wired to the outgoing terminal block of the unit to provide external indication of the following conditions:

Input AC supply fail.

d. The charger must be large enough to provide for a 100 percent increase in the charging needs of the batteries for future sets.

e. Battery charger with suitable cut-out circuit shall be provided for charging battery from EB mains when DG is not running. Suitable capacity dynamo shall be provided for charging the batteries when DG is in operation. A separate voltmeter and ammeter shall be provided for monitoring battery voltage and current.

f. CAPACITY

180 Ah 12 V - 4 Nos.

q) ACOUSTIUC ENCLOSURE

The acoustic enclosure is made of 1.6 mm thick CRCA sheets and structural/ sheet metal base frame painted in Munsell shade. The walls of the enclosure are insulated with fire retardant Rock wool.

The enclosure has the following features:

i. Designed to have optimum power out of Genset without any de-rating factor.

ii. Designed to have sufficient approach, operation and service space.

iii. Air inlet louvers specially designed to provide sufficient fresh air availability for operation of the D.G.set.

iv. Made on special purpose CNC machines for consistency in quality and workmanship

v. Powder coated for long lasting service life and superior finish

vi. With UV resistant powder coating, withstands extreme environments

vii. Use of special hardware for longer life

viii. Insulation material meets exacting IS 8183 specifications for better sound attenuation

ix. Flush styling - no projections

x. Fluid drains for lube oil.

r) PROPELLER FANS

Propeller fans shall have MS powder coated or epoxy coated diaphragm. The impellers shall be die cast aluminium or MS powder coated epoxy coated with adequate gauge sheet. The fans shall be statically and dynamically balanced. The fans shall be suitable for mounting vertically and should withstand higher temperatures. The fans shall be suitable for 3-phase operation as specified in the tender conditions. The vendor shall clearly determine whether propeller fans are required and confirm expressly at the time of tendering itself.

Note: Other than GI sheet of insulation works all other materials shall be powder coating.

Axial Fans

The tunnel axial fans shall be designed, manufactured and tested in accordance with the latest

revision of the following standards.

International Standards Organisation (ISO):

ISO 281 Rolling bearings: dynamic load ratings and rating life

ISO 1680 Test code for the measurement of airborne noise emitted by rotating electrical machinery: engineering method for free field conditions over a reflecting plane

ISO 5135 Noise: Air distribution and diffusion

ISO 8821 Mechanical vibration: balance. Balancing shaft and fitment key convention

ISO 117 Method of testing the performance of jet fans Underwriter's Laboratories. Inc. (UL):

508 Industrial Control Equipment.

The minimum design life for all equipment covered by this specification shall be 20 years.

s) FUEL HANDLING SYSTEM

i. DAY TANK (990 L Capacity)

a. The design and construction of the tank shall comply with:

- IS: 10987:1992 and the other complimentary and reference standards stated there in.
- Rules and Regulations of the Chief Inspector of Explosives
- India Petroleum Rules 1956.

b. All site welding shall be carried out by fusion welding. For all butt welds, the root run and final run shall be carried out.

c. The HSD tanks shall be of min 3 mm thick M S construction, horizontal, cylindrical in shape with plain ends and shall be suitable for storage of fuel up to a maximum temperature of 50 Deg C at atmospheric pressure. Tanks shall be painted externally to prevent corrosion and shall have a reflecting surface.

d. The external surface of the storage tanks shall be cleaved to remove rust, scale, etc. and apply two coat of zinc chromate anti-rust primer followed by two coats of finishing paint - epoxy paint.

e. The tank shall be designed for a pressure of 0.05 MPA when full of water. Minimum corrosion allowance of 1.5 mm shall be considered. The design temperature shall be the lowest one-day mean temperature where the tank is to be installed.

f. The following accessories shall be part of the tank:

- Filling point and drain off point
- Dip Connection
- Vent pipe
- Over flow pipe
- Drain-pipe
- Continuous Level gauge with dial type indicator on top of the tank.
- 550 mm dia manhole with cover and locking arrangement.
- High /Low level sensors
- Lifting lugs
- Painting with Anti corrosive treatment.
- Spill tray to be located below the tank and all around it
- Metal Support structure, wear plates, stiffeners etc

ii. PIPING

All fuel piping shall be minimum 25mm dia M.S Class B and as per IS: 1978 and IS: 2062. All fittings shall be of heavy duty. Flanges shall conform to ASA-Class 150 weld neck. The piping shall generally be installed in already prepared underground trenches with fixing hardware as required.

iii. VALVES

All valves shall be ball type and of cast steel body with gunmetal or stainless-steel ball only. All the valves shall be pressure tested as per ASA-class 150. The valves shall confirm to IS 10611, IS 11792.

t) Inspection, Testing and Dispatch

i. Inspection and testing shall be carried out based on this specification and with approved drawings certified by the consultant / Client. The Client and their consultants shall have the right to carry out stage inspection and shop visit to review the manufacturing progress. All routine and type tests specified shall be carried out during final inspection. 15 days advance notice shall be given for carrying out the final inspection.

ii. Any fuel charges for load testing shall be included in the offer, which shall be indicated separately in the Offer. Bidder shall ensure that a competent testing authority calibrates all meters and equipment used testing and the calibration certificates are valid at the time of carrying out test. After completion of inspection and testing Bidder shall furnish all as built.

iii. documents in two sets. Only on receipt of final documents the release order for dispatch of equipment shall be issued.

u) DELIVERY AND HANDLING

The engine/generator sets shall be delivered to site properly packaged and mounted on pallets or skids to facilitate handling of heavy items. Factory- fabricated type containers or wrappings shall be utilized for engine/generator and components, which shall protect equipment from damage. Engine-driven generator equipment shall be handled carefully to prevent physical damage to equipment and components. Any damaged equipment shall be removed from site and replaced with new equipment.

v) INSTALLATION AND COMMISSIONING

i. Installation & Commissioning shall be carried out based on the latest requirement of the various statutory authorities such electrical inspector, factory inspector, pollution control board, regulatory authority, and any other statutory agency appointed by the purpose by the state / central / municipal bodies. The document / drawings required for obtaining the approval shall be prepared by the bidder.

ii. The Bidder shall obtain the approval for the installation from all the above agencies. All official payment made for such approvals shall be reimbursed at actual on submission of original receipts.

iii. After installation as per the final approved drawing, the Bidder shall carry out the site testing as specified in presence of consultant. DG shall be taken over by Client only on acceptance by the consultant and satisfactory test results.

iv. The Employer shall witness the commissioning.

v. A minimum of seven working days' notice shall be given to the Consultant / Employer prior to the start of commissioning.

vi. A Specialist Agency approved by the Consultant / Employer shall be responsible for the testing and satisfactory performance of the complete synchronizing system.

w) SITE REGULATIONS FOR INSTALLATION WORK

i. Site discipline shall be observed by all the Bidders / erection Contractor's personnel inside the premises of the site. The Contractor and his personnel shall abide by all the rules and regulations laid down by the client. The Contractor shall be required to carry out the installation work simultaneously with other installation work being executed by other Contractor and shall extend all co-operation required.

ii. Electrical Power required for construction, installation and commissioning of DG shall be provided by the client at one point near meter location. The Bidder shall have his own cabling and switch gear for power distribution to his work place. Cabling and switchgear arrangement shall be provided in accordance with rules and regulation duly approved by the consultant.

iii. Purchaser/Client will not be responsible for any damages / compensation payable in case of any accident/injuries to any of the Contractor's personnel. In case of any accident at site in connection with the execution of work Contractor shall report the accident within 24 hours to the client. All transports of material to and from site shall be marked clearly and visibly and shall be accompanied by appropriate documents.

x) SERVICE

Manufacturers shall have established network of service centers capable of servicing the specified equipments. The Personnel shall be factory trained and shall be available for servicing

y) PROPOSED LAYOUT

The diesel generator units and their auxiliaries will be installed in the DG Building ground floor. Supplier shall recommend his layout and indicate space requirement. The DG sets will be arranged to draw air from outdoors. Exhaust will be discharged through a vertical mounted muffler into individual exhaust pipe.

Contractor shall indicate the number of air changes required for site conditions for safe operation of DG set. Manufacturer shall indicate the heat load to be removed from DG set room.

z) Documentation and Testing

The following documents, drawings etc shall be submitted along with the offer:

- Technical document of AVR, Governor, etc.
- Schematic diagram of engine control panel with accessories like AVR on details etc.
- Single line diagram for the whole system – control and power
- Detailed specification sheet for all auxiliary components giving material specifications, make / model, capacity, rating etc.
- Foundation details.

aa) TESTING

The following tests shall be carried out at the Bidders works for the assembled DG Set in

presence of Consultants / Architects / Clients.

i. Routine tests shall be conducted in the presence of Client / Consultant at the factory before shipping by simulating faults to check the proper functioning of the Generators and Alternators.

ii. Load test using water load shall be carried out in the presence of Client / Consultant to prove the efficiency of the system.

iii. Alignment between engine and alternator by authorized representative from the company.

iv. Operational test for satisfactory functioning.

v. Relay tests – wherever applicable.

vi. Insulation resistance check on alternator and relay panel (if relay panel is supplied by DG vendor)

vii. TEST ON ENGINE

- 25% load for 1 hour.
- 50% load for 1 hour.
- 75% load for 1 hour.
- 100% load for 1 hour followed by 30 min. running at 110% of load

viii. TESTS ON CONTROL PANEL

- Insulation resistance test
- High voltage withstand test
- Functional and operation test
- Secondary injection test on meters & relays :
- Mechanical testing of components.

ix. SITE TESTING

(To be carried out by Bidder witnessed by Client if factory test is not conducted):

a. Load test for one hour at full load.

b. 100% load for 1 hour followed by 30 min. running at 110% of load AMF sequence checking with all interlocks in line. Measurement of starting time from cold condition.

c. Load will be provided by customer. Consumables (for excess of first fill) will be provided by the customer.

bb) INSPECTION, OPERATION, MAINTENANCE MANUALS

The bidder shall submit the type test and routine test certificates along with delivery of DG set. Bidder shall submit two sets of as built drawings, operation and maintenance manual, Spare parts manuals of all components duly certified by the consultants after installation.

cc) AS BUILT DRAWINGS

Bidder shall submit dimensional drawing showing location of all equipments inside the acoustic room housing the DG set and the cable route.

dd) PRODUCT DATA SHEET

Enclosed elsewhere in this document, vendors go through and provide inputs wherever necessary and confirm parameters asked for.

ee) TRAINING

The Employer 's technical team shall be trained in all aspects of operation, maintenance and administration of the system

ff) STATUTORY CLEARANCES

The Bidder will be responsible for the statutory clearances from the electrical inspector, pollution control board (lab report), regulatory authority, and any other statutory agency appointed for the purpose by the state / central / municipal bodies. The documents / drawings required for obtaining the approval shall be prepared by the bidder.

gg) SPECIAL NOTES

Major civil works like RCC foundation etc in not included in the scope. However, All other works and materials, tools, tackles, hardware, consumables, fuel, oil etc. including grouting of the foundation bolts, metal support structure, scaffolding as required and necessary hardware to complete and commission the installation is deemed as included in the offer unless specifically stated and agreed to by the Client before the placement of order.

The Bidder shall be responsible for providing foundation drawings and load calculation to the Consultant / Client for making necessary foundations.

hh) ENERGY CONSERVATION APPLICATIONS

Please furnish the various methods that have been adopted in the engine, alternator and fuel systems to produce maximum energy per litre of diesel consumed with statistical data's.

ii) SPECIFIC REQUIREMENTS

A. NOISE LIMIT FOR GENERATOR SETS RUN WITH DIESEL

a. Noise limits for diesel generator sets, shall be as follows:

b. Noise from DG set shall be controlled by providing an acoustic enclosure or by treating the room acoustically, at the users end.

c. The acoustic enclosure or acoustic treatment of the room shall be designed for minimum 25 dB (A) insertion loss or for meeting the ambient noise standards, whichever is on the higher side (if the actual ambient noise is on the higher side, it may not be possible to check the performance of the acoustic enclosure/acoustic treatment. Under such circumstances the performance may be checked for noise reduction upto actual ambient noise level, preferably, in the night time). The measurement for Insertion Loss may be done at different points at 0.5 m from the acoustic enclosure/room, and then averaged.

d. The DG set shall be provided with proper exhaust muffler with insertion loss of minimum 25 dB(A).

e. These limits shall be regulated by the State Pollution Control Boards and the State Pollution Control Committees.

B. Guidelines for the manufacturers/users of Diesel Generator sets shall be as under:

a. The manufacturer shall offer to the user a standard acoustic enclosure of 25 dB(A) insertion loss and a suitable exhaust muffler with insertion loss of 25 dB(A).

b. The user shall make efforts to bring down the noise levels due to the DG set, outside his premises, within the ambient noise requirements by proper siting and control measures.

c. Installation of a DG set must be strictly in compliance with the recommendations of the DG set manufacturer.

d. A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

C. REQUIREMENT OF CERTIFICATION

Every manufacturer or importer (herein after referred to as "supplier") of DG set (herein after referred to as "product") to which these regulations apply must have valid certificates of Type Approval and also valid certificates of Conformity of Production for each year, for all the product models being manufactured or imported from 1st July, 2003 with the noise limit specified in paragraph above.

D. SALE, IMPORT OR USE OF DG SETS NOT COMPLYING WITH THE RULES PROHIBITED

No person shall sell, import or use of a product model, which is not having a valid Type Approval certificate and Conformity of Production certificate.

E. NODAL AGENCY

- The Central Pollution Control Board shall he the nodal agency for implementation of these regulations.
- In case of any dispute or difficulty in implementation of these regulations, the matter shall be referred to the nodal agency.
- The nodal agency shall constitute a Committee to advise it on all matters; including the disputed matters, related to the implementation of these regulations.

F. AUTHORIZED AGENCIES FOR CERTIFICATION

The following agencies are authorized to carry out such tests as they deem necessary for giving certificates for Type Approval and Conformity of Production testings of DG sets and to give such certificates: -

- Automotive Research Association of India, Pune
- National Physical Laboratory, New Delhi
- Naval Science & Technology Laboratory, Visakhapatnam
- Fluid Control Research Institute, Palghat
- National Aerospace Laboratory, Bangalore

G. COMPLIANCE AND TESTING PROCEDURE

The compliance and testing procedure shall be prepared and published by the Central Pollution Control Board, with the help of the certification agencies.

H. Emission standards for diesel engines (engine rating more than 0.8mw (800kw) for power plant generator set applications and other requirements

1. EMISSION LIMITS

The emission limits for new diesel engines more than 800 kw, for gensets applications shall be as given in the Table below:

Parameter		Area Category	Total engine rating of the Plant (includes existing as well as new generators sets)	Generator sets commissioning date		
				Before 1/7/2003	Between 1/7/2003 And 1/7/2003	On or after 1/7/2005
Nox(as NO2)(AT 15% O2), dry basis, in ppmv		A	Upto 75MW	1100	970	710
		B	Upto 150MW			
		A	More than 75MW	1100	710	360
		B	More than			

			150MW			
NMHC (as C) (at 15% O2), mg/Nm^3		Both A & B		150	100	
PM (at 15% O2), mg/Nm^3	Diesel Fuels- HSD & LDO	Both A & B		75	75	
	Furnace Oils- LSHS & FO	Both A & B		150	100	
CO (at $_{mg/Nm^{15\%02}}$3),		Both A & B		< 2%		
Sulphur content in fuel		A		< 4%		
		B				
Fuel specification		For A only	Up to 5MW	Only Diesel Fuels (HSD,LDO) shall be used		

Stack height (for generators sets commissioned after 1/7/2003)	Stack height shall be maximum of the following, in meter:	
	i.	14 $Q^{0.3}$, Q = Total SO2 emission from the plant in kg/hr.
	ii.	Minimum 6m above the building where generator set is installed.
	iii.	30 m.

2. Applicability

These rules shall apply to all new diesel engines for genset applications (herein after referred to as 'engine') manufactured in India and all diesel engines for genset applications and diesel gensets (herein after referred to as 'product'), imported into India, after the effective date: Provided that these rules shall not apply to:

- Any engine manufactured or engine or product imported for the outside India, or; purpose of export
- Any engine or product intended for the purpose of sample only and not for sale in India.

3. Requirement of Certification

Every manufacturer of engine or every importer of engine or product must have valid certificates of Type. Approval and certificates of Conformity of Production for each year, for all engine models being manufactured or for all engine or product models being imported, after the effective date with the emission limit as specified in paragraph 1.

4. Requirement of Conformance Labeling

a. All the engines (individually or as part of the product) shall be clearly engraved 'Genset Engine' on the cylinder block.

b. The engine or the product must be affixed with a conformance label meeting the following requirements: -

- The label shall be durable and legible;
- The label shall be affixed on a part necessary for normal operation of the engine or the product and not normally requiring replacement during the life of the engine or the product.

c. The conformance label must contain the following information:

- Name and address of the engine manufacturer or the engine or product importer (if the address is given in the owner's manual, it may not be included in the label);
- Statement that 'this engine or product conforms to the Environment (protection) Rules, 1986';

- Type approval certificate number;
- Date of manufacture of engine or in case of import, the date of import of the engine or the product.

5. Compliance with BIS Specifications

All engines up to 20 kw (individually or as part of the product) shall carry ISI mark and meet relevant BIS specifications (IS 1000 1).

6. Nodal Agency

The Central Pollution Control Board shall be the, nodal agency for implementation of these rules.

In case of any dispute or difficulty in implementation of these rules the matter shall be referred to the nodal agency.

The nodal agency shall constitute a Committee to advise it on all matters, including the disputed matters, related to the implementation of these rules.

jj) AUTHORISED AGENCIES FOR CERTIFICATION

The following agencies are authorized to carry out such tests as they deem necessary for giving certificates of Type, Approval and Conformity of Production tests for Diesel engines and to give such certificates: -

Automotive Research Association of India

kk) AUTHORISED AGENCIES FOR CERTIFICATION

The compliance and testing procedure shall be prepared and published by the Central Pollution Control Board with the help of the Certification Agencies.

ll) FUEL SPECIFICATION

The specification of commercial fuel applicable for -diesel gensets shall be the same as applicable for commercial HSD (High Speed Diesel) applicable for diesel vehicles in the area, from time to time."

Bidder shall submit dimensional drawing showing location of all equipments inside the acoustic room enclosure housing the DG sets. The hard and soft copy of proposed DG set is to be enclosed with foundation details.

5.2.5 HT Cables & LT Cables

1. Scope

This specification covers the technical requirements of design, manufacture, test at manufacturer's works, packing & forwarding, supply, storage, and erection of HT & LT cables.

2. GENERAL

a. This specification covers the technical requirements of design, manufacture, test at manufacturer's works, packing & forwarding, supply, storage and erection of HT & LT cables.

b. Principally all cables shall consist of one length. Connecting sleeves / joints are not allowed, except, the connection points are allowed by the Authority Engineer.

c. For energy cables the cable dimensioning shall be in accordance with the relevant standards, and shall have a diameter assuring, that voltage drop is not more than 10 % to the nominal voltage from the transformer to the most distant supplied electrical facility.

d. The cables shall also have such diameters that, if there is a short circuit at the furthest point to the circuit breaker, the circuit breaker cuts off efficiently without exceeding the cable's rated temperature rise.

e. Cables shall be brought to the site on cable reels or cable drums and shall be secured with close- fitting battens. Cables with kinks or abrasions will not be accepted for installation.

f. The installation of the cables is only allowed in / at the required cable routes. The Contractor shall be fully responsible for the protection of the cables against damage while they are stored, installed, or worked with.

g. The Contractor shall give complete information of all cables to the engineer for his approval.

h. All cables shall be installed generally along the routes and in the manner indicated on the drawings in accordance with the notes and instructions thereon.

i. Sufficient and adequate apparatus and equipment necessary for the unloading, handling, transportation and installation of the cables shall be provided by the Contractor at his own expense, the apparatus and equipment must not be removed from the site without the authorization of the engineer.

j. The Contractor shall take all necessary precautions to prevent damage to cables during laying / installation.

k. Whenever cables are installed during other work at this site still being incomplete, the Contractor shall take all reasonable precautions to protect the cables against damage arising from the execution of other works.

l. All cables shall directly run from point to point without joints unless the needed cable length required is not obtainable in one piece from the cable manufacturers. In such a case, the engineer has to approve the position of each and every joint. No other joints shall be permitted unless they are specifically called for in this specification or at the drawings.

m. Where a cable shall change direction, whether horizontal or vertical, the radius of the bend must not be less than the minimum bending radius specified in the IEE Wiring Regulations and / or the cable manufacturer's specifications. So the bending radius of the cables shall be kept as large as possible.

n. Wherever a cable is cut, for whatever reason, the ends of both portions shall be immediately re- sealed. Cables shall be sealed by means of an approved plastic cap embracing the armour wires and outer sheath. No other form of temporary capping shall be accepted.

3. APPLICABLE STANDARDS

The equipment shall conform to latest relevant applicable Indian Standards. Equipment's complying with any authoritative standards such as British, U.S.A., V.D.E. IEC etc. will also be considered if it assures performance equivalent to or superior to standards listed below. In such cases, bidder shall clearly indicate the latest standard / standards adopted and furnish a copy of the English version / translation of the same. Should there be any dispute of design, standard the most stringent shall be followed: -

IS-8130	Conductor for insulated electric cables & flexible cords
IS-398(Part-IV)/1994	Aluminum Alloy Conductors
IS-5831	PVC insulation and sheath of electric cables
IS-7098 (Part-II)	Cross-linked polyethylene insulated thermoplastic sheathed Cables (Part-II)
IS-5216	Guide for safety procedures and practices in electric works
IEC-228	Conductor for insulated cables
IEC-502	Extruded solid dielectric insulated power cables for rated Voltages from 1 KV up to 30 KV

IEC-540	Test methods for insulations and sheaths of electric cables and cords.
NFPA 502	Standard for Road Tunnels, Bridges, and other limited Access Highways
IS-3975	Mild steel wires strips and tapes for armoring cables
BS-5468	Cross-linked polyethylene insulation of electric cables
IEC-840	Test for power cables with extruded insulation

Indian Electricity Rules

Indian Electricity Act

The Electricity Act 2003

The design, manufacture and performance of the equipment and services provided under this specification shall comply with the standards, rules, regulations and acts given in this specification.

4. HT Power Cables

a. GENERAL TECHNICAL REQUIREMENTS:

This specification covers Design, Engineering, Manufacturing, Testing, packing at manufacturer's works and Delivery of 11 KV (E), FRLS, PVC Insulated, XLPE insulated, galvanized steel flat wire armoured cable.

All cables shall be suitable for installation in air, conduits, ducts; open concrete trenches, for direct burial in either wet, or dry locations for normal operating conditions.

b. GENERAL CONSTRUCTIONS:

The cross-linked polyethylene insulated (XLPE) Cable shall be manufactured and tested strictly in accordance with the Indian Standard IS 7098 (Part – II) and its latest amendments.

All material used in the manufacturing of cables shall be new and shall be selected as the best available for the intended use.

c. CONDUCTORS

All conductors shall be of stranded construction complying with the requirement of class II of IS: 8130 with latest amendments. A conductor filling (strand blocking) is required to inhibit water migration along the conductor. This material may be viscous semi conductive liquid or swelling powder and capable of 90 degree Celsius continuous operation. The filling material shall be compatible with the semi conducting & insulating compounds in the cable. In addition, the filling shall have zero flow & no drip at temperature below 90 degree Celsius and it must not harm the electrical conductivity of the conductor or joint. The supplier shall describe the method of preparing the filled central conductor for jointing.

All conductors shall be of high electrical conductivity Aluminium conforming to requirement of IS: 8130 with latest amendments.

Before stranding, the conductor shall be circular in cross section, uniform in quality, solid, smooth and free from scale, sharp edges and other defects.

d. CONDUCTOR SCREEN

Conductor screening shall consist of a layer of extruded semi-conducting compound as per IS – 7098 (Part-II) with latest amendments.

The semi-conducting compound shall be suitable for the operating temperature of the cable and compatible with the insulating material.

e. INSULATION

The insulating material shall be Cross Linked Polyethylene (XLPE) as per IS-7098 and its latest amendments. The insulation shall be an extrusion cross linked polyethylene fire retardant material rated for 90-degree Celsius continuous operation.

The insulation properties shall be stable under thermal conditions arising out of continuous operation at conductor temperature of 90 degree Centigrade rising momentarily to 250 Degree Centigrade under short circuit conditions.

It shall be free from any foreign material or porosity visible to the unaided eye. The insulation shall be so applied that it fits closely on the conductor and it shall be possible to remove it without damaging the conductor.

The average thickness of insulation shall not be less than the nominal value as specified in IS: 7098 (Part II) with latest amendments. No tolerance on the negative side shall be acceptable.

The insulating material shall have excellent electrical properties with regard to resistivity, dielectric constant and loss factor and shall have high tensile strength and resistance to abrasion. This shall not deteriorate at elevated temperatures or when immersed in water. The insulation shall be preferably fire resistant and resistant to chemicals like acids, alkalies, oils and ozone.

f. INSULATION SCREEN:

Extruded Semi-conducting screening and metallic screening of copper tape shall be generally as per IS: 7098 (Part-II) with latest amendments.

The semi conducting compound shall be suitable for the operating temperature of the cable and compatible with the insulating material.

g. CORE IDENTIFICATION:

Individual core of multi-core cables shall be colour coded and/or numbered for proper identification in accordance with the IS: 7098 (Part – II).

h. LAYING UP OF CORES:

In three core cables, the cores shall be laid together with a suitable right hand lay. The interstices shall be filled with non-hygroscopic material.

Further, the compounds used with fillers shall be such as to have no deleterious effect on other components of the cable and to be stable at cable temperatures.

i. INNER SHEATH:

The laid-up cores shall be provided with inner sheath applied by extrusion process. It shall be ensured that the shape is as circular as possible. It shall be applied to fit closely on to the laid-up cores and shall be possible to remove easily without causing any damage to the underlying insulated cores and screens.

The thickness of the inner sheath shall be as per IS: 7098 (Part - II). No tolerance on the negative side shall be acceptable.

j. ARMOURING:

The armouring shall be of galvanized steel flat wires for multi core cables. The armouring shall be applied as closely as practical. The galvanized steel wires shall comply with the requirements of IS: 3975 with latest amendments. The dimensions of the galvanized steel wire shall be as per IS: 7098 (Part-II). No tolerance on the negative side shall be acceptable.

k. OUTER SHEATH:

The outer sheath shall be of polyvinyl chloride (PVC) compound conforming to the requirements of Type ST 2 of IS: 5831 with latest amendments. The outer sheath shall be applied by extrusion process.

The thickness of the outer sheath shall be as per IS: 7098 (Part - II). No tolerance on the negative side shall be acceptable.

- PACKING:

Cables shall be furnished in the specified lengths. Drums (wooden or steel as specified) shall be strong, weatherproof, and non-returnable. Wooden drums shall be as per IS 10418-1982 and its latest amendments. The ends of the cable shall be suitably sealed by means of non-hygroscopic sealing material.

5. LT Power Cables - 1.1kV grade, Copper conductor, Power cables

a. Scope

This section covers the technical specifications for design, engineering, manufacturing, inspection, testing at manufacturer's works, packaging, and delivery by road (properly packed in non-returnable steel drums), 1.1KV grade, Multi-stranded Copper conductor, XLPE insulated, extruded PVC inner sheathed, GI round-wire armoured, extruded FRLS PVC ST2 outer sheathed. Power Cables for effectively grounded system, conforming to the latest revisions of IS: 7098 (Part –I), 1988 & as per the technical specifications given below.

b. STANDARDS

The design, manufacture and testing of the cable shall comply with the latest editions/amendments of the following Indian Standards, unless otherwise specified. Equipment complying with equivalent standards shall also be acceptable.

a)	IS-7098, 1998 (Part-I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto 1100V.
b)	IS-3961	Recommended current ratings for cables
c)	IS 8130-1984	Specification for conductors insulated electric cables and flexible cords.
d)	IS-3975, 1999	Low Carbon galvanized steel wires, formed wires & tapes for armouring of cables
e)	IS-4759	Specifications for Hot dipped galvanized coating on round steel wires
f)	IS-5831	PVC insulation and sheath of electric cables
g)	IS-10418	Drums for electric cables.
h)	IS-10810(Part 0 to 64)	Method of test for cables.

c. SERVICE CONDITION

The cable shall be designed with the following service conditions into consideration:

i. Cables shall be capable of satisfactory operation under a power supply system frequency variation of +3% and voltage variation of ±10%.

ii. Cables shall be suitable for laying in conduits, ducts, trenches, channels, trays, racks or for direct buried in ground in both dry and wet locations with chances of flooding by water.

iii. The cables shall be suitable for the following ambient condition:

Ambient Air temperature: -15 deg C to +30 deg C

Ambient ground temperature: 30 deg C

iv. The current rating shall be based on maximum conductor temperature depending on the type of insulation for continuous at the rated current.

v. The one second short circuit current rating values shall be furnished and shall be subjected to the purchaser's approval.

vi. The cables will have current ratings and de-rating factors as per relevant.

vii. Indian Standards.

Full technical details and descriptive literature shall be furnished indicating the construction details, standard applicable for the components of the cable and current ratings of the cables in air and ground. De-rating factors to be considered for the ambient temperature, ground temperature, de-rating due to cable location in air and ground shall also be furnished. The certificates for the type tests conducted on cables similar to the cables covered herein shall be submitted along with the tender.

d. DESIGN AND CONSTRUCTION PARTICULARS

i. General

The cables supplied under this specification shall be adequate insulated to operate continuously at the specified voltage with a high degree of safety and reliability throughout the life of the cables. The sheathing material shall be high quality PVC based compound. The construction of cable shall be as per IS: 7098 (Part I) - 1988.

Cable shall be designed and manufactured to prevent damage during transportation, installation & operation under all climatic & operating conditions to which cable may be subjected to.

Table 8: TECHNICAL PARAMETERS OF 1.1kV XLPE CABLES

i.	Quantity	As per BOQ
ii.	Packaging	Steel drum packaging, each having single length cable ≥ 500 metres.
iii.	Cable Type	A2XWY/ 2XWY
iv.	No. of Cores	3/3.5/4
v.	Voltage Level	1.1kV
vi.	System Grounding	Solidly Grounded
vii.	Nominal System voltage	400V ±10%
viii.	Nominal System Frequency	50Hz ±3%
ix.	Maximum conductor temperature at rated current	90°C
x.	Maximum conductor temperature at Short-circuit	250°C
xi.	Conductor	
	Conductor Material	Electrolytic grade Copper, Purity > 99.97%
	Conductor type	Stranded with number of strands as per IS 8130 (Part-I) 1984
xii.	Insulating material	Cross-Linked-Polyethylene (XLPE) Compound
xiii.	Core Identification Strips	Red, Yellow, Blue & Black (for neutral)
xiv.	Material of Inner Sheath	FRLS, PVC ST-2 Compound
xv.	Armour	Single layer of Galvanized Steel Round Wire according to IS-3975
xvi.	Outer Sheath	FRLS, PVC ST-2 Compound according to IS-5831

ii. Conductor

- Copper:

The conductors shall be made from high conductivity copper rods complying with IS: 613-1964. The conductor material used shall be electrolytic grade with high purity. Two sample conductor randomly selected from finished lot of cables, shall be tested for its purity at any 3rd party NABL accredited lab.

- Cable Joints:

Joints shall be permitted in the individual wires of which the conductor is formed, but no joint shall be within 300 mm of any other joint within the same layer. The joints shall be made by resistance butt welding, fusion welding, cold pressure welding, electric welding, gas welding, brazing or silver soldering. No joint is allowed in the conductor after stranding. A maximum of two joint shall be allowed in any strand forming complete length of the cable.

The conductors shall conform to appropriate dimensions, resistance and number of wire in the conductor (number of strands) as given in IS 8130 (Part I): 1984.

iii. Insulation

The insulating material for power cables shall be extruded cross linked polyethylene (XLPE) compound as per IS-7098(Part-I)-1988. The minimum thickness of insulation shall not be less than the values specified in Table-2 of IS-7098 (Part-I)-1988. No negative tolerance shall be applicable for the thickness. The insulation of the cable shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stress under steady state and transient operating conditions. The cores shall be identified as per the following colour scheme:

3-Core - Red, Yellow & Blue

3 ½ or 4-Core - Red, Yellow, Blue & Black

iv. Inner Sheath

The inner sheath shall be extruded FRLS PVC, Type ST2, compatible with thermal rating of insulation conforming to IS-6380-1984. The sheath shall have adequate thickness, mechanical strength and elasticity, as specified in IS 5831. The material shall be soft thermoplastic type, applied by extrusion method. The thickness of the inner sheath shall be as per IS: 7098 (Part I) and the color of the inner sheath shall be Grey. The inner sheath shall be so formed that it fits closely on the laid up cores and could be easily removed without damaging insulation. One or more layer of proofed plastic tape shall be provided over the laid up core before extrusion.

v. Armouring

The armouring arranged over the inner sheath shall consist of one layer of galvanized round steel wires for all sizes of cable. The armour round wire used on the cable shall conform to IS: 3975 for all requirements. The direction of lay of armour shall be opposite to that of the cores. The zinc coating on the galvanized steel strip shall comply with relevant standards.

The joints in armour wires/strips shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire/strip shall be at least 300 mm away from the nearest joint in any other wire/strip in the completed cable.

vi. Outer Sheath

Extruded outer sheath shall be provided over the armouring. The material used for sheathing shall be FRLS PVC sheath, Type ST-2 base compound conforming to IS 1554/ IS 5831 for power cable. The outer sheath shall be so formed that it fits closely on the laid-up armour and could be easily removed without damaging the intermediate sheath and insulation. The colour of the outer sheath shall be black. The thickness of outer sheath shall be in accordance with the IS 1554 (Part-I)-1988. Suitable additives shall be added to prevent

attack by rodents and termites. All serving must be given anti-termite treatment.

Cables shall have suitable fillers laid up with the conductor to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the temperature of the cable and compatible with the insulating material. The material shall be of the best quality and workmanship. The fillers and sheath material shall be non-hygroscopic. All materials shall be new, unused and of the finest quality.

e. TESTS

All the tests specified below shall be carried out in accordance with the Indian Standards by the manufacturer in the presence of Purchaser's representative. If the cable fails to pass the test specified, the Purchaser shall have the option to reject it. Shipping release shall be obtained from the Purchaser's representative. The Purchaser, however reserves the right to waive off the inspection.

The tests at works shall include electrical, mechanical and hydraulic tests in accordance with the appropriate clauses of Statutory Regulation, relevant codes and standards, in addition any test called for by the Purchaser or his representative to ensure that the equipment being supplied fulfils the requirement of the specification.

For test not covered by any code or specifically mentioned in this specification, the test procedures are to be agreed with the Purchaser.

f. Pre-Dispatch Inspection:

i. The manufacturer shall be given at least 15 days advance notice prior to the commencement of testing, so that Purchaser's representative can plan to witness the tests.

ii. All the tests indicated in the test clause of this specification shall be carried out in the presence of Purchaser's representative by the manufacturer and shall provide all the facilities and equipment for testing.

iii. Six copies of the Test Certificate shall be furnished to the Purchaser for approval prior to dispatch of cables from factory.

iv. Visual check to conform the details given in this specification is to be done. In addition to the above, the general workmanship of the cable drums and cables laid in drums shall be checked.

v. Manufacturer shall have proper test set up for testing all the routine tests & type tests on finished cables as per IEC.

g. Type Test

Type tests on four randomly selected cable drums will have to be conducted in the presence of the department's representative. The test samples will be taken from finished cables. This test shall be in accordance to IS: 7098, Part-1,1988.

i. Test on Conductor

- Annealing test for copper conductors
- Tensile test for aluminium conductor
- Wrapping test for aluminium conductor
- Conductor Resistance Test

ii. Test on Insulation

- Physical dimension measurement
- Tensile strength and elongation at break
- Hot set test
- Shrinkage test
- Ageing in air oven

- Water absorption test

iii. Test on round Armour

- Physical dimension measurement
- Tensile strength
- Elongation at break
- Torsion test for round wires
- Winding test for firmed wire
- Mass of zinc coating.
- Uniformity of zinc coating
- Resistivity measurement, Resistance test for armour

iv. Test on Sheath

- Physical dimension measurement
- Tensile strength & Elongation at break test
- Ageing in air oven
- Loss of mass in air oven
- Shrinkage test
- Hot deformation test
- Heat shock test
- Thermal stability test

v. Insulation Resistance Test

vi. High Voltage Test at room temperature

vii. Volume resistivity at room temperature & at 90o C. (IS-10810-Part 43)

viii. Flammability test

ix. Test requirement of FRLS inner and outer sheath

The inner and outer sheath of cables shall meet the following test requirements related to flame retardant, low smoke emission, low acid and toxic gas emission. The BIDDERs shall have proper test apparatus to conduct all the relevant tests as per the applicable standards:

x. Flame retardant test on single cable

xi. Oxygen Index Test

The critical oxygen index value shall be minimum 29 when tested at 27+2ºC as per ASTMD-2863

xii. Temperature index test

Temperature index value shall be minimum 250ºC at oxygen index of 21 when tested as per NES 715.

xiii. Smoke Density Test

The cables shall satisfy the tests conducted to evaluate the percentage obscuration by smoke in an optical system placed in the path of the smoke. The maximum smoke density rating shall not be more than 60% when tested as per ASTM-D-2843.

xiv. Acid Gas Generation test (halogen acid gas evolution)

The hydrochloric acid generation when tested as per IEC 754-1 shall be less than 20% by weight.

xv. Test for specific optical density of smoke

xvi. Anti termite and rodent property test

The sequence of electric tests shall be as per the relevant Indian/International standards. The Bidder shall submit the sequence of tests for the approval of the purchaser before conducting the tests. A copy of the adopted standard shall also be supplied.

xvii. Routine Test (On each drum)

The following routine tests shall be carried out by the Manufacturer on each and every length of the cable in the presence of Purchaser's representative at manufacturer's works.

- Resistance test for conductors
- Insulation resistance test
- High voltage test

xviii. Conductor purity test

Two samples of copper shall be taken from any of the finished set of cables at random and the sample shall be tested for its purity at a NABL accredited lab.

xix. Qualifying Criteria:

The test results should be within limits as per IS 7098. All the routine tests as per IS 7098 / IEC shall be conducted and passed as per the limits given in the standards. All the bought-out certificates will be verified and the test results shall be as per respective standards.

h. IDENTIFICATION

The following details shall be marked sequentially for each meter run length of the cable by non-erasable embossing on the outer sheath:

- Reference to Indian Standard
- Name of the manufacturer/ Trade Name
- Name of the project: CWMF, BARC (K)
- Configuration of the cable: viz. Voltage grade, no. of Core, Sq. mm, A2XWY/2XWY/YWY / YY as applicable
- Year of manufacturing
- Sequential marking of running meter length

The running length of the cable shall be identified at regular intervals of one meter (Increasing order from inner end to outer end of the cable)

i. PACKAGING

- Each drum shall consist of single length cable ≥ 500 metres.
- The cable shall be wound on non-returnable steel drums of suitable size, packed and marked.
- Packing shall be sturdy to protect the cable from any injury during transportation, handling and storage. The cut ends of the cable shall be sealed by means of non-hygroscopic sealing material preferably Heat shrinkable end caps.
- One end of the cable shall be brought out of the drum and suitably clamped to the drum flange with proper mechanical protection. Location of the other end may be marked on the drum.
- The cable shall be placed on drums in such a manner that it will be protected from injury during transit. Each end of the cable shall be firmly and properly secured to the drum. No undue stress shall appear on cables when laid on drums.
- The cable drum shall carry the following information stenciled on a metallic label, securely

attached to each end of the drum:

Reference to the Indian standard

Manufacturer's name, brand or trade mark

Type of cable and voltage grade

No. of cores

Nominal cross-sectional area of conductor

Cable code

Length of cable on drum

No. of lengths on reel, drum or coil (if more than one)

Gross weight

Country of manufacture

Year of manufacture

Direction of rotation of drum (an arrow)

ISI certification mark

j. GUARANTEE

All the cables shall be guaranteed against faulty material, defective design & poor workmanship for a period of 18 months from the date of supply. The materials becoming defective during the guarantee period shall be replaced free of cost and the defects arising out of the works shall be rectified free of charge without delay.

6. Fire Survival Cables/Control Cables

The cables shall be multicore, colour coded, annealed stranded high conductivity copper, single conductor, insulated with PVC insulation, PVC sheathed, conforming to IS / relevant IEC standards.

Table 9: TECHNICAL PARTICULARS OF FIRE SURVIVAL CABLE

1.0		Type of Cable	EPR INSULATED FIRE SURVIVAL CABLES
2.0		Standard applicable in general (Latest amendment to be referred if any)	IS-9968(PART-1), IS-6380, IS -10810,IS 10418, IS-3975, ASTMD:2843, ASTMD-2863, IEC-60754-1, IEC-60331-1, IEC-60332, IEEE-60383,SS-424-1475
3.0		Voltage Grade	1.1 KV
4.0		Number of cores, cross sectional area of	As per BOQ-Cum-Price Schedule
5.0			
(a)		Material	Copper
		Grade and Class	Stranded, Tinned annealed high conductivity, Class 2
(b)		Standard Applicable	IS - 8130
(c)		Shape	Compacted circular / Shaped
(d)		Min. number and diameter of strands	As per class -2 of IS 8130
(e)		Fire Barrier tape (separator tape)	Glass Mica tape in two layers with minimum 50% overlap

6.0		**INSULATION**	
(a)		Material	Heat resistant Elastomer compound , type IE2
(b)		Standard Applicable	IS : 9968(Part-1),IS -6380
(c)		Continuous withstand	90°C
(d)		Short-circuit	250°C
(e)		Method of application	By extrusion; sleeve extrusion not permitted.
(f)		Method of curing	Dry/Steam/Gas/Sioplas
(g)		Nominal Thickness of insulation	As per IS : 9968(Part-1)
(h)		Fire proof tape	Two Layers of plain Glass Fibre Binder Tape
7.0		**CORE IDENTIFICATION**	Colour coding as per IS : 9968(Part-1)
8.0		**INNER SHEATH**	
(a)		Material	Heat resistant, oil resistant , flame retardant (HOFR) Elastomer compound
(b)		Grade and type	Extruded Type SE-3
(c)		Standard Applicable	IS : 9968(Part-1)
(d)		Colour	Black
9.0		**ARMOUR**	
(a)		Material:	
(i)		Single core cables	Single layer of Hard Drawn Aluminium Round Wire of H4 grade
		Standard Applicable	IS 8130
(ii)		Multi-core cables	Galvanised Steel Round Wire / Galvanised Steel Formed Wire Strip
		Standard Applicable	IS-3975
(b)		Gap between armour wires	Shall not exceed one armour wire space (No cross-over/ over-riding)
(c)		Minimum Coverage	90%
(d)		Breaking load of joint	95 % of normal armour
			Zinc rich paint shall be applied on armour joint surface of GS wire
10.0		**OUTERSHEATH**	
(a)		Material	Heat resistant, oil resistant , flame retardant (HOFR) Elastomer compound
(b)		Grade and type	Extruded Type SE-3
(c)		Colour	Black
(d)		Marking	Cable size (cross section area and no. of cores) and voltage grade, IS 9968-Part II @ 5m (by embossing) Word "EPR" "FS" etc, @ 5m (by embossing) Manufacturer's name and/ or trade name, and year of manufacture @ 5m (by embossing) 'NFR and 'CUSTOMER' Name @5m (by embossing) Progressive sequential marking @ 1m (by embossing/ printing)
11.0		**HOFR**	
(a)		Oxygen index	≥30 (as per ASTMD 2863)

(b)		Temperature Index	≥350ºC (as per ASTMD-2863)
(c)		Acid gas generation	≤ 2% by weight (as per IEC-60754-1)
(d)		Smoke density rating	≤ 20% (As per ASTMD 2843)
(e)		Water absorption test	IS 10810-28
(e)		**Flammability Test**	
(i)		Flammability test for single cable	As per IEC-60332 Part-1
(ii)		Flammability test for bunched cables	As per IEC-60332 Part-3 CAT-B
(iii)		Flammability test for complete cable	As per IEEE-60383
(iv)		Swedish Chimney test	As per SEN-SS-424-1475-F3
(f)		***Fire survival test***	As per IEC -60331-11 for min 3 Hrs at 950ºC
12.0		**Allowable Tolerance**	±2 mm (max.)
13.0		**CABLE DRUMS**	
(a)		Type of Drum	Wooden Drum as per IS 10418 / Steel Drum As per Annexure I
(b)		Standard drum length	500m (±) 5% (as specified in BOQ-Cum-Price
(c)		Painting	Entire surface to be painted
(d)		Outermost Layer	To be covered with water-proof polyethylene
(e)		Particular information on Drum	Both the end of cables shall be properly sealed with heat shrinkable PVC / rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage & erection. Wood preservative anti-termite treatment shall be applied to the entire drum.

NOTE: Suitable fire-retardant material fillers shall be used for filling in the interstices. Two layers of plain glass binder tape should be applied over the laid-up cores.

7. Cable Trays

Cable Tray and Cable Ladder systems are intended for the support and accommodation of cables and possibly other Electrical equipment in Electrical/Instrumentation/Communication systems.

a. DESIGN AND FABRICATION OF CABLE TRAYS / LADDERS:

i. The cable trays / ladders shall be fabricated according to the design specified by IEC 61537 and should be tested for Safe Working Load (SWL). The relevant details of SWL and the load chart with respect to SWL, supporting distance and the deflection should be according to the following chart.

Safe Working Load (SWL) with a span length up to 3 meters						
Description	Side Height (in mm)	Width (in mm)	Span length (in meters)			
			1.5m	2m	2.5m	3m
			Permitted Load (in kg/meter)			
Perforated Cable Tray	35	50 – 300	125	90	50	-
	60	50 – 600	150	100	50	-
	85	100 – 600	175	110	50	-
	110	100 – 550	185	130	75	60
Cable Ladder	45	200 – 600	180	140	100	55
	60	200 – 600	-	225	150	100

	110	200 – 600	-	310	200	140		
Safe Working Load (SWL) with a span length up to 10 meters								
Description	Side Height (in mm)	Width (in mm)	Span length (in meters)					
			4m	5m	6m	7m	8m	9m	10m
			Permitted Load (in kg/meter)						
Perforated Cable Tray for long span distance	110	200 - 300	160	110	75	-	20	-	-
		400 - 600	200	150	100	-	40	-	-
	160	200 - 300	230	180	140	100	70	-	-
		400 - 600	250	200	160	130	100	-	-
Cable Ladder for long span distance	110	200 - 300	160	110	80	40	-	-	-
		400 - 600	210	150	100	70	-	-	-
	160	200 - 300	230	180	140	100	70	-	-
		400 - 600	250	200	160	130	100	-	-
	200	200 - 600	-	-	300	250	200	140	100

ii. Fabrication of Tray / Ladder and accessories at site and welding is not permitted. In unavoidable circumstances, If any cut or holes are made in the trays/Ladder/ accessories, zinc spray need to be applied over the surface. The metal edge has to be protected by edge protection sleeves to avoid cable damage. Edge of the supports has to be protected with plastic END caps. Screwed connections and internal fixing Devices should not create any damage to the cable when correctly fixed. Sudden or jerky motions shall not be used to tighten reusable screw connections.

iii. Cables shall run in cable tray/ladder mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures using mounting accessories.

iv. The cable tray and all accessories shall be fabricated from sheet steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both indoor and outdoor applications & should have a Base Perforation Class B according to IEC 61537. The cable trays shall be supplied in standard lengths of 3000mm and the width of the tray shall be as follows.

Width: 50, 100, 150, 200, 300, 400, 500, 600 & 750 mm.

v. All the cable tray accessories like Bend's, TEES's, Cross over's etc should be designed in accordance with IEC 61537 and shall be factory fabricated. The accessories shall be from the same material as of the tray and modular type, it should be connected with the trays by using fasteners. Typical details of trays, fittings and accessories etc are shown in the enclosed drawings.

vi. For Cable trays designed, tested and confirming to IEC 61537, thickness of cable tray should be according to the manufacturer's catalogue. For locally fabricated and non-tested tray, thickness should be 2 mm up to span length of 1.5-meter, 2.5 mm for span length between 2 to 3 meter and 3 to 4 mm for span length between 4 and 10 meters.

vii. Cable Ladder:

- The cable Ladder and all accessories shall be fabricated from sheet steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both

indoor and outdoor applications & should have a Free Base Area classification Y according to IEC61537. The cable ladders shall be supplied in standard lengths of 3000/6000 mm and the width of the tray shall be as follows.

Width: 200 to 1200 mm in multiples of 100 mm

- Maximum rung spacing in the ladder shall be 300mm. The rung's should be made of C profiles suitable to fix cables by special metal clamps according to the drawing. The ladder shall be of riveted and foldable type for easy transportation and to avoid damage during transportation and storage. All the ladder accessories like Bend's, TEES's, Cross over's etc should be designed in accordance with IEC 61537 and shall be factory fabricated. The accessories shall be made from the same material as of the ladder and modular type; it should be connected with the ladder by using fasteners. The details of ladders, fittings and accessories .etc are shown in the enclosed drawing.
- For Cable Ladders designed, tested and confirming to IEC 61537, thickness of cable Ladder should be according to the manufacturer's catalogue. For locally fabricated and non-tested Ladder, thickness should be 2.5 mm up to span length of 1.5 to 2 meter, 3 mm for span length between 2.5 to 4 meter and 3 to 4 mm for span length between 5 and 10 meter

b. SPECIFICATION FOR HOT DIP GALVANIZING PROCESS

(For Mild Steel Used for Earthing, Cable Trays or Junction Boxes for Electrical Installation.)

i. Quality of Zinc

Zinc to be used shall conform to minimum Zn 98 grade as per requirement of IS:209-1992.

ii. Coating Requirement

Minimum weight of zinc coating for mild steel flats with thickness upto 6 mm in accordance with IS:6745-1972 shall be 400 g/sqm.

The weight of coating expressed in grams per square metre shall be calculated by dividing the total weight of Zinc by total area (both sides) of the coated surface.

The Zinc coating shall be uniform, smooth and free from imperfections as flux, ash and dross inclusions, bare patches black spots, pimples, lumpiness, runs, rust stains bulky white deposits, blisters.

Mild steel flats / wires shall undergo a process of degreasing pickling in acid, cold rinsing and then galvanizing.

c. COVER FOR CABLE TRAYS / LADDERS

Cover for trays/ladders to protect the cable insulation from falling objects, water droplets, harmful effects of ultraviolet rays and accumulation of dust. The cover shall be made either from Hot Dip Galvanized sheet steel or superior quality Double Dip Galvanized Sheets. For Outdoor application, Double dip Galvanized material shall be used. The covers should be fitted properly to the Ladder / Tray by using pre fixed and tested locks which ensure that covers are fitted rigidly to Tray / Ladder. For outdoor application in high wind areas, additional cross over beadings to be used for fixing the cover on tray / ladder of width more than 500 mm.

d. MOUNTING ACCESSORIES (SUPPORTS AND BRACKETS):

The mounting accessories shall be fabricated from steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both indoor and outdoor applications and should be of completely modular type.

All supports and Brackets should be factory made, hot dip galvanized after completing welding, cutting, drilling, other machining operations and tested according to IEC 61537 according to the arrangements in the enclosed drawing. The system shall be designed such that it allows easy assembly at site by using Bolts and Nuts. The main support and brackets shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hard ware etc to form various arrangements required to support the cable trays. Welding of the

components at the site shall not be allowed.

Joints

Joints shall be smooth and without projections or rough edges that may damage the cables.

The Contractor will be required to cover joints with rubber cement or other non hardening rubberised or plastic compounds if in the opinion of the Department joints may damage cables.

Joints shall as far as possible be arranged to fall on supports. The two cable tray ends shall butt tightly at the centre of the splice and the splice shall be bolted to each cable tray be means of at least 8 round head bolts, nuts and washers. Splices shall have the same finish as the rest of the tray.

e. FIXING TO SUPPORTS

Trays shall be bolted to supports by at least two round head bolts per support. Bolts shall be securely tightened against the tray surface to avoid projections which might damage cables DURING INSTALLATION.

f. FIXING TO THE STRUCTURE

Where installed on concrete or brick, the supports for cable trays and ladders shall be securely fixed by means of at least 2 heavy duty, expansion type anchor bolts. Cantilevered trays shall be supported by a minimum of two expansion bolts per support.

It is the responsibility of the Contractor to ensure that adequate fixing is provided since cable trays and ladders that work loose shall be rectified at his expense. The fixing shall take in to account site conditions that prevail during installation.

Horizontal trays and ladders shall in general be installed below slabs, ceilings, etc. to

facilitate access during installation of cables.

Multiple runs shall be spaced at least 300 mm apart unless a different spacing is specified.

Corrosion Protection:

The cable tray / ladder/accessories shall be of HOT DIP Galvanized (ISO 1461-1999) for installations in corrosive atmospheres both indoor and outdoor application. Sample tray / ladder / accessories / mounting accessories and supports should be salt spray tested according to ISO 9227 for > 500 hours. (*550 hours according to class 6 for Hot dip Galvanized surface as per ISO)

g. TESTING AND CERTIFICATION IF INSTALLATION :

Cable tray / Ladder, bend, T Bend, cross, and all supports are to be tested for Safe Working Load (SWL), deflections, Impact resistance, Salt Spray & Electrical continuity test according to IEC 61537. The cable tray/ladder should not deflect more than 1/100th of the span length at SWL in Mid span and the transverse deflection of all mounting accessories at SWL shall not exceed 1/20th of the length. The cable tray / cable ladder should be tested up to 1.7 times SWL at minimum and maximum room temperature. The temperature classification of cable tray system should be - 5 to + 150°C.

h. MARKING, DOCUMENTATION, COMPLIANCE AND INSPECTION:

Each system component shall be durably and legibly marked with:

- the manufacturers or responsible vendor's name or trade mark or identification mark;
- a product identification mark which may be, for example, a catalogue number, a symbol, or the like.

  When system components other than cable tray lengths and cable ladder lengths are supplied in a package, the product identification mark may be, as an alternative, marked on the smallest package unit.

  Marking shall be applied, by moulding, pressing, engraving, printing, adhesive labels, or

water slide transfers. Compliance is checked by inspection and, for marking on the product, by rubbing by hand for 15 s with a piece of cotton cloth soaked with water and again for 15 s with a piece of cotton cloth soaked with petroleum spirit. Marking made by moulding pressing, or engraving is not subjected to the rubbing test. After the test, the marking shall be legible.

If a system component is stored and transported at a temperature outside the declared minimum and maximum temperatures, the manufacturer or responsible vendor shall declare the precautions and the alternative temperature limits. Compliance is checked by inspection.

The manufacturer or responsible vendor shall provide in his literature all information necessary for the proper and safe installation and use of the cable tray system and cable ladder system. The SWL and impact resistance is valid for the whole temperature classification declared. The information shall include

i. FIRE RETARDANT CABLE PAINT & FIRE BARRIER

The fire retardant paint / barrier shall be listed by independent test agencies such as UL, FM or OPL and be tested to, and pass the criteria of ASTM E 814 (UL1479) standard test method for fire test through- penetration fire stops and ASTM E 1996 (UL 2079) standard test method for fire resistive joint system/

j. FIRE RETARDANT CABLE PAINT

The Fire-resistant cable coating / painting shall be intumescent / ablative, water based compound, The coating shall expand up to 10 times, supplied in a manufacturer seal container indicating manufacturing and expiry dates. The coating material shall be non-toxic, asbestos free, & halogen free and shall have good mechanical strength. The colour of paint shall be white and density of coating shall be 1.3kg/ltr, coating shall have a snap time of 30 minutes, the expansion shall begin at 230 deg.C and it shall have a oxygen index of 41%.

Coating shall be applied by ordinary paint brush after cleaning the cables of dust and oil deposition. A minimum textured finish of 3 mm wet film thickness shall be achieved by applying the material in 2-3 layers leaving intervals of 2 to 8 hours depending upon the moisture and thickness, moisture and temperature hours between each coat.

k. FIRE BARRIER SHEET FOR FLOOR AND WALL SEALING

The framing & fixing part of fire barrier sheet shall be very simple & directly fixed around walls & floors by help of anchored bolts & washer. For 2-hour fire rating the fire barrier sheet shall be minimum 7.62 mm thick and shall be cut as per the profile of penetration and opening. The small gap left around the penetration shall be closed with fire rated soft & mouldable putty. Fire barrier must be design on the intumescent technology to seal larger penetration through the fire rated walls & floors. Fire barrier must be a composite construction with the quality incorporated with organic/ inorganic fire resistive elastomeric sheet with specific **gravity** of 1.6 gm/ cubic centimeter.

5.2.6 LT Panel

1. General Requirements

This specification covers requirements for Supply, Erection, Testing and Commissioning of LT Panels. The equipment offered by the Contractor shall be complete in all respects. Any material and component not specifically stated in this specification but which is necessary for trouble free operation of the equipment and accessories specifically excluded. All such equipment / accessories shall be supplied without any extra cost. Also, all similar components shall be interchangeable and shall be of the same family type and rating for easy maintenance and low spare inventory.

The general power supply of the 433 / 250 Volt-level to the different equipment will occur from the Electrical room in the Control Centre on both ends of the tunnel to the Niches and then further to the ultimate consumers through field distribution boards.

At the Control Building one low voltage main distribution cabinet is situated for Grid and one for the UPS from where the Grid and UPS power is supplied to the Niches and then further to the ultimate consumers.

All power and control units shall be installed into distribution cabinets, all different voltages (e.g. main power, UPS power, different control units and so on) shall be placed in separated cabinets.

2. Code and Standards

Compliance with all applicable Indian standards, Indian Electricity Act and Indian Electricity rules.

IS 5039	:	Distribution Feeder Pillars
IS 375 / 1963	:	Making and arrangement for switchgear, bus-bars, main connections & auxiliary wiring
IS 694	:	PVC insulated cables for working voltages up to and including 1100V.
IS 13779	:	A.C. Static Electricity Meters.
IS 1248	:	Electrical Indicating instruments.
IS 1567 / 1960	:	Metal clad switches (Current rating not exceeding 100A)
IS 1951 / 1916	:	Polyvinyl chloxide sleeving for electric purposes.
IS 2147 / IS 12063	:	Degree of protection provided by enclosures for low voltage switchgear and control gear.
IS 5	:	Colors for ready-mixed paints and enamels.
IEC 60947/ IS 13947 (Part-2)	:	A.C. Circuit breakers.
IS 8828	:	Miniature Circuit breakers.
IS 12640	:	Residual Current Operated Circuit breakers.
IS 2448 / 1962	:	Adhesive insulating tapes.
IS 2551	:	Danger Notice Plates.
IS 2705	:	Current Transformers.
IEC 60947/ IS 13947	:	Contactors and motors starter for voltages not exceeding 1000 V AC or 1200 V DC.
(Part-4, Sec-1)	:	
IS 13947 (Part-5, Sec-1)	:	Control Circuit Devices and Switching Elements
IS 13947 (Part-1&5)	:	Actuators, Indicators
IS 13947 (Part-1&5)	:	Timers
IS 3043	:	Code of practice for earthing.

IS 3072	:	Installation and Maintenance of switchgear.
IS 3202	:	Code of practice for climate proofing of electrical equipment.
IS 3231/ IS 8686	:	Electrical relays for power system protection.
IS 4237	:	General requirements for switchgear and control gear for voltages not exceeding 1000 V.
IS 5082	:	Wrought Aluminum & Al alloy for electrical purposes.
IS 6875	:	Switches and push-buttons.
IS 8623	:	Specification for factory-built assemblies of switchgear & control gear for voltages up to & including 1000 V AC.
IS 10118	:	Code of practice for selection, installation and maintenance of switchgear and control gear.
IS 11353	:	Guide for uniform system of marking and identification of conductors and apparatus terminals.
IS 12021	:	Specification of control transformers.

Equipment in line with any other authoritative / internationally recognized standards such as IEC, British, USA and German etc. shall also be considered if it ensures performance equivalent or superior to Indian Standards. Prior approval shall be obtained from consultant for use of this equipment / material. In such cases the decision of consultant shall be final and binding.

3. Quality Assurance

Manufacturers regularly engaged in manufacture of panel boards and enclosures, of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years

4. Guarantee

Manufacturer shall provide guarantee for work under this section. However, such guarantee shall be in addition to and not in lieu of all other liabilities which manufacturer and Contractor may have by other provisions of the contract document.

The Panel Boards shall be guaranteed against trouble free operation, defective workmanship, materials and design for a period of 18 months from the date of supply or 12 months from the date of erection and commissioning, whichever is earlier. Any defects during this period shall be rectified free of cost.

5. Submittals

Contractor to submit general arrangement diagrams with front, side, top and bottom view and inside view.

General arrangement diagrams shall include outline and dimensions, voltage, main bus capacity, circuit breaker details and their arrangement / sizes.

All drawings shall also indicate location / description of all operating / indicating components mounted on the front / rear of the panel for all feeders / starters.

Typical control schematic diagram for each type giving designation to be refereed on Single Line Diagram/BOQ.

Terminal block details for all feeders / starters power and control terminals provided for external as well as internal wiring connections.

Panel board foundations with necessary dimensions.

Details of shipping sections along with all dimensions.

Bill of material giving make / rating / catalogue number of all components of the complete switch board.

Shop drawings to scale of the room layout indicating the panel location

6. Delivery

All panels shall be carefully packed to avoid damage during transit. Panel boards shall be wrapped in polyethylene sheets for local shipment, whereas for outstation delivery in addition to polyethylene sheet the panels shall be packed in wooden crates to prevent damage to the finish.

7. Panel Board Enclosures and Accessories

Constructional Details of Panel Boards

All Panel Boards shall be metal enclosed, indoor, floor / wall mounted, free-standing type.

All Switchboards frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2.0mm. Frames shall be enclosed in cold rolled sheet steel of thickness not less than 2.0mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6mm. Stiffeners shall be provided wherever necessary. Rear doors shall min 2.00 mm thick CRCA and provided with three pin handle and lock.

All panel edges and cover / door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members. The top covers of the panels should be designed such that they do not permanently bulge / bend by the weight of maintenance personnel working on it.

The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cutouts shall be true in shape and devoid of sharp edges.

All LT Panels shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 54 as per IS: 2147.

All Feeder Pillars and Secondary Panels shall be of dust-proof, vermin-proof and weather-proof construction and shall be provided with a degree of protection of IP : 55 as per IS : 2147.

All cutouts shall be provided with synthetic rubber gaskets. The gaskets, wherever specified, shall be of good quality synthetic rubber with good aging, compression and oil resistance characteristics suitable for panel applications. Preference shall be given to Heat resistant – EPDM Gaskets.

Panels shall be supplied with base frames made of structural steel sections, along with all necessary provision for fixing to foundation / floor as required. The base frame height shall be such that floor finishing to be done by Owner after erection of the switchboards does not obstruct the movement of doors and cover etc.

All Panel Boards shall be divided into vertical section, comprising of various compartments as mentioned below. However, these compartments may be combined in case of Feeder Pillars and Secondary Panels.

Feeder Pillars and Secondary Panels shall have canopy on the top. Canopy shall have slope so as not to let the rainwater accumulate on the same. The canopy shall extend beyond the panel body to avoid any rainwater falling inside the panel.

Bus-bar Compartment

A completely enclosed bus-bar compartment shall be provided for the horizontal and vertical bus-bars. Bolted covers shall be provided for access to horizontal and vertical bus-bars and all joints for repair and maintenance, which shall be feasible without disturbing any feeder compartment. All bus-bars shall be in separate compartment. Covers shall be provided with name plates indicating “Danger - Bus Bars” on it. Colour of

the plate shall be White with letters in Red of danger name plates shall be inscribed with 6 mm size lettering.

Shrouding for Bus Bar with above 1250 A current rating shall be provided. These shrouds located near conductors shall be made using non-magnetic materials.

Switchgear / Feeder Compartment

All equipment associated with an incomer or outgoing feeder shall be housed in a separate compartment of the vertical section. The compartment shall be sheet steel enclosed on all sides. The front of the compartment shall be provided with the hinged single leaf door with "Master Key" lock. The feeders compartment door shall have two number anodized inscription plates. One inscription plate shall bear the feeder number and feeder rating and fixed to the door with rivets. The other inscription plate shall bear the feeder name and shall be fixed by screws. The feeder name plates shall be interchangeable.

Cable Compartment or Cable Alley

A full-height vertical cable alley of minimum 300mm width shall be provided for power and control cables. Cable alley shall have no exposed live parts and shall have no communication with Bus-bar compartment. Cable terminations located in cable alley shall be suitably shrouded to prevent accidental contact by falling of tools etc. It shall be of such construction as to allow cable cores with lugs to be easily inserted in the feeder compartment for termination. The Contractor shall furnish suitable plugs to cover the cable openings in the partition between feeder compartment and cable alley. Cable alley door shall be hinged. Cable alley door shall be provided with name plates indicating "Cable Alley" on it.

Control Compartment

A separate compartment shall be provided for relays and other control devices associated with a circuit breaker.

Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboards, except for the horizontal Bus-bar compartment. Synthetic rubber gasket shall be provided between the panel sections to avoid ingress of dust into panels. Each shipping section shall have full metal sheets at both ends for transport and storage.

After isolation of power and control circuit connections it shall be possible to safely carryout maintenance in a compartment with the Busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose. Wherever two breaker compartments are provided in the same vertical section, insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.

All 415 V switchgear (circuit-breaker) panels shall be of single-front type. All Panels shall also be of single-front construction. All single-front switchboards shall be provided with single-leaf, hinged or bolted covers at the rear. The bolts shall be of captive type. The covers shall be provided with 'Danger' labels. All panel doors shall open by 90deg. or more. The panel door shall be openable only after switching of the incoming power supply.

Complete shrouding / segregation shall be provided between incoming and outgoing bus links of breakers. In case of bus coupler breaker panels, the bus-bar connection to and from the breaker terminals shall be segregated such that each connection can be approached and maintained independently with the other bus section live.

All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. The internal layout of all modules shall be subject to consultants approval and shall be provided with bakelite shrouding.

The tentative power and control cable entries (top/bottom) required are indicated in the "Bill of Quantity". However, the Owner / Consultant reserve the right to alter the cable

entries, if required during detailed engineering, without any additional commercial implication.

Each switchboard shall be provided with un-drilled, removable type gland plate, which shall cover the entire cable alley. Contractor shall ensure that sufficient cable glanding space is available for all the cables coming in a particular section through gland plate. For all single core cables, gland plate shall be of non-magnetic material. The gland plate shall be provided with gasket to ensure enclosure protection.

Gland Plates

Gland plates for 2 Core, 3 Core, 3½ Core, 4 Core Cables shall be 2.5 mm thick CRCA zinc passivated. Thickness of zinc passivation shall be 100 microns. Wherever, the size of gland plates exceeds 600 mm same shall be split into two parts and provided with adequate supporting arrangement. Earth continuity between cable armour and panel body shall be maintained. Single core shall have aluminum gland plates of min 6mm thick.

Clearances

The minimum clearance in air between phases and earth for the entire run of horizontal and vertical busbars and bus-link connections at circuit-breaker shall be 25mm. For all other components, the clearance between "two live parts" shall also be twenty-five (25) mm throughout. For a live part and an earthed part the clearance shall be twenty (20) mm minimum. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for horizontal and vertical bus-bars the clearances specified above should be maintained even when the bus-bars are sleeved or insulated. All connections from the bus-bars up to MCCB / SFU / FSU shall be fully shrouded / insulated and securely bolted to minimize the risk of phase to phase and phase to earth short circuits.

Power Bus-bars and Insulators

All 415 V Panel Boards, shall be provided with three phase and neutral bus-bars. Entire Bus-bar system shall be insulated with colour coded, heat shrinkable PVC sleeves.

All bus-bars and jumper connections shall be of high conductivity aluminum alloy / copper of adequate size.

The cross-section of the bus-bars shall be uniform throughout the length of switchboard and shall be adequately supported and braced to withstand the stress due to the specified short circuit currents. Neutral Bus-bar short circuit strength / cross section shall be same as main bus-bars up to 400 Amps.

All bus-bars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet moulded compound or equivalent type polyester fiber glass moulded insulators. Separate supports shall be provided, for each phase and neutral Bus-bar. If a common support is provided, anti-tracking barriers shall be provided between the supports. Insulator and barriers of inflammable material such as Bakelite / Hylam, shall not be accepted. The Bus-bar insulators shall be supported on the main structure.

All copper to aluminum joints shall be provided with suitable bi-metallic washers. Alternatively direct Bus Bar joints can be made between copper and aluminium Bus Bar if tinned copper Bus Bars are used.

All bus-bars shall be colour coded as per IS: 375.

All bus-bars shall have PVC sleeves (not tapes) wherever called for in the specification.

Earth Bus and Earthing

A galvanized steel / aluminum earth bus of suitable size shall be provided at the bottom of each panel and shall extend throughout the length of each Panel. It shall be welded / bolted to the framework of each panel and breaker earthing contact bar.

The earth bus shall have sufficient cross section (250 sq. mm. minimum) to carry the momentary short circuit and short time fault current to earth, without exceeding the allowable temperature rise.

Suitable arrangements shall be provided at each end of the horizontal earth bus for bolting earthing conductors. The horizontal earth bus shall project out of the Panel ends and shall have predrilled holes for this connection. All joint splices to earth bus shall be made through at-least two bolts, and taps by proper lug and bolt connection.

All non-current carrying metal work of the Panel shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosure framework and truck shall be maintained even after painting.

All metallic cases of instruments and other panel-mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. All the equipment mounted on the door shall be earthed through flexible wire / braids. Insulation colour code of earthing wires shall be green.

CT secondary neutral point earthing shall be at one place only, i.e. on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit can be removed without disturbing the earthing of other circuit.

All hinged doors having potential carrying equipment mounted on it shall be earthed by flexible wire / braid. For doors not having potential carrying equipment mounted on it, earth continuity through scraping hinges / hinge pins of proven design may also acceptable. The Contractor shall establish earth continuity at site also.

Switchgear:

i. LT Air Circuit Breakers (ACB's)

Technical Parameters

The ACB shall conform to the requirements of IEC 60947-2 / IS 60947-2 and shall be type tested & certified for compliance to standards from–CPRI, ERDA / any accredited international lab. The circuit breaker shall be suitable for 415 V + 10%, 50Hz supply system. Manufacturer should submit Combined sequence test certificate from CPRI/ERDA

The circuit breakers shall be for continuous rating at -15 to 30 deg C ambient temperature. The Rated insulation voltage shall be 1000 volts AC & Rated impulse withstand Voltage shall be 12kV for main circuit.

Rated service short Circuit Breaking capacity shall be 50KA and should be equal to the Rated ultimate Short circuit breaking capacity (Icu) and short circuit withstand values (Icw) for 1 sec.

Constructional Features

The ACB shall be 3/ 4 pole with modular construction, horizontal draw out type, manually or electrically operated version as specified in BOQ and fully interlocked.

Main current carrying contacts of ACB shall be silver plated and suitable arcing contacts with proper arc chutes shall be provided to protect the main contacts. Arc chutes shall be provided for each pole, and these shall be suitable for being lifted out for the inspection of the main and the arcing contacts without using any tools.

The ACB shall be provided with a door interlock i.e. door should not be open when circuit breaker is closed and breaker should not be closed when door is open.

All 4 Pole ACBs should have 100% neutral rating.

Cradle

The Circuit Breaker cradle shall be designed and constructed to permit smooth withdrawal and insertion. The movement shall be free of jerks, easy to operate and positive.

The draw out Circuit Breaker shall have the following 3 distinct and separate positions wrt cradle.

"Service" -- Both main and secondary isolating contacts closed

"Test" -- Main isolating contacts open and secondary isolating contacts closed

"Isolated" -- Both main and secondary isolating contacts open

Circuit Breaker Interlocking

It shall not be possible for the Breaker to be rack out / withdrawn from the cubicle when in the "ON" position.

It shall not be possible for the Breaker to be switched "ON" until it is either in the fully inserted position or, for testing purposes, it is in the fully isolated position.

It shall not be possible for the Circuit Breaker to be plugged in unless it is in the OFF position.

Circuit Breaker Auxiliary Contacts & accessories

The Circuit Breaker shall have minimum 4 NO/NC auxiliary contacts rated at 16 amps 415 volts 50 Hz. These contacts shall be approachable from the front. They shall close before the main contacts when the Circuit Breaker is plugged in and vice versa when the Circuit Breaker is Drawn Out of the cubicle.

All accessories of ACBs like shunt trip coil, under voltage trip coil, closing coil etc. shall be click fit type and front mounted. It should be possible to know the control voltage ratings for all electrical accessories without opening the panel door.

External Neutral CT should be provided for all 3 pole ACBs for Earth Fault sensing & to avoid nuisance tripping due to unbalance loads.

Mechanical operation counter to be provided for all ACBs

Protective Devices

All ACBs (except bus couplers) shall be provided with micro-controller based release to offer accurate and versatile protections with complete flexibility and in the following zones:

- Overload (Phase & Neutral) protection with adjustable time delay.
- Short time protection with intentional delay.
- Instantaneous protection.
- Ground fault protection with intentional time delay.

The release should provide local LED indication for identification of type of fault, without requiring using external power supply.

The release shall draw its power from the main breaker CTs and shall require no external power supply for its operation, There shall be provision for aux. supply for display of parameters during off or lightly loaded conditions.

The release should display actual % loading at any instant.

Release shall be password protected to prevent unauthorized access to protection settings

Releases shall have 2 storable sets of LSIG protection settings to provide adequate protection against loads varying as per time & source changeover from Transformer to DG.

The release shall meet the EMI / EMC requirements.

Metering & Communication: Release should have LED/LCD display for of Phase & Neutral currents and last 20 fault / trip history.

Transformer & DG set Incomer ACB releases shall have LED/LCD display showing all Power & Energy Parameters (I, Imax, %loading, Iavg, V, Freq, PF, W, VAr, VA, Wh, VArh,

Vah, MD-Active, MD-Reactive, MD-Apparent, Temperature in each Phase)

The release shall also give additional protection against Current & Voltage Unbalance, Under Voltage, Over Voltage, Under frequency, Over frequency, Lead/Lag PF, Maximum Demand, Phase Sequence etc

All Main Incomer ACBs shall have inbuilt Temperature rise protection for protection against abnormal Temperature rise at terminals.

The Release shall be provided with RS485 communication port on MODBUS RTU protocol

Safety Features

- Draw out ACBs shall be provided with automatically operated safety shutters to prevent accidental contact with live contacts when breaker is withdrawn from the Cradle.
- IFor safety of users, interlock should be provided between breaker operating mechanism & the arc chutes to prevent closing in case the arc chutes are not properly secured.
- The insulation material used shall conform to Glow wire test as per IEC60695-2-1
- The racking shutter should open only when ACB is OFF to avoid unauthorized racking operation.
- Mechanical and electrical anti pumping devices shall be incorporated in the electrically operated ACB's as required.

ii. Moulded Case Circuit Breakers (MCCB's)

The Moulded case circuit Breaker (MCCB) shall confirm to the latest IS 13947 (Part-2) and IEC 60947-2. The MCCB shall comply with the isolation function requirement of IEC 60947-2 Section 7.12 & marked as suitable for isolation and disconnection to facilitate safety of operating personnel while the breaker is in use.

The MCCB shall have a rated service short circuit breaking capacity (Ics) not less than 25/40/50/65 KA rms at 415V, 50 Hz AC, 400 A & 250 A as specified in SLD.

The Service breaking capacity (Ics) shall be equal to ultimate breaking capacity (Icu) unless otherwise specified.

MCCB's shall be suitable for rated operation voltage upto 690 V AC, 50 Hz & rated insulation voltage upto 750 V AC, 50 Hz.

MCCBs shall be of triple pole / four pole construction. Operating mechanism shall be quick-make, quick-break and trip-free type. The "ON" , "OFF" and "TRIP" positions of the MCCB's shall be clearly indicated and visible to the operator when mounted as in service. Front of door operating handle shall be provided with pad lock and door interlock. Front of door operating handle shall be provided with door interlock defeat mechanism to facilitate inspection of the MCCB during 'ON' position.

The MCCB shall be current limiting type. MCCB shall have Arc extinguishing device contained in a compact, high strength, heat resistance, flame retardant, halogen free insulating moulded case with high withstand capability against thermal and mechanical stresses.

The trip command of releases in MCCB shall over ride all the other commands. The MCCB shall employ maintenance free double break contact system to minimise the let through energies and capable of achieving Discrimination up to the full short circuit capacity of the downstream MCCB. The MCCB shall not be restricted to line / load connections. MCCB shall be provided with test trip Push Button to check the proper function of tripping mechanism.

MCCBs shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relay settings of the motor starting equipment and the mechanical stress caused by the peak short-circuit current of value associated with the switchgear rating. The maximum tripping time under short

circuit shall not exceed 8 milliseconds.

Where mechanical interlocking is called-for between two Incomer and Bus Coupler or between two Incomers without Bus Couplers, proper arrangement for built-in Ronis/ Coded key interlocking shall be provided.

MCCB terminals shall be shrouded and designed to receive Bus Bar Links /cable lugs for cable sizes relevant to circuit ratings.

Protection

MCCBs shall be provided with Thermo-Magnetic / microprocessor type releases 400 & 250 A, TPN.

The MCCB's above 250 Amps shall be provided with fully interchangeable thermo-magnetic / microprocessor based overload and short circuit release. Load indication LED shall be integral part of electronic releases. All electronic releases shall be EMI / EMC compatible.

Microprocessor Releases shall have Thermal Memory i.e. when the breaker shall re-close after tripping on overload, then the thermal stress caused by the overload if not dissipated completely, shall get stored in the memory of releases and this thermal memory shall ensure reduced tripping time in case of subsequent overloads and earth fault. Realistic Hot/Cold curves shall take into account the integrated heating effects to offer closer protection to the system.

Where Earth fault protection are indicated they shall be integral with MCCB's and have adjustability from 20% to 100% of rated current with adjustable time delays to aid discrimination on earth faults. The integrated system shall be immunized against nuisance tripping as per IEC 61000-4 standards.

In case of 4 Pole MCCB the neutral shall be defined and capable of offering protection upto full rating (0/50/100% value of phase current). In case of critical supply feeder, neutral protection shall be 0/80/160% of phase current.

Accessories

The MCCB shall have common field fittable snap-on auxiliaries for entire range & above 160 Amps the accessories like tin plated spreaders and phase Barriers should be integral part of MCCB's.

Indicating Instruments (Digital Type)

All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96mm. Square size Digital Type with Built-in Selection, and shall have an accuracy class of 1.0 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction. Digital meters to be provided for single phase Panels shall not incorporate Built in Selector Switch.

All instruments shall be compensated for temperature errors and factory calibrated.

Instrument Transformers

All current transformers shall be tape insulated type suitable for continuous operation at the temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated condition and the specified ambient temperature. The class of insulation shall be 'E' or better.

All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block where star point formation and earthing shall be done.

CT shorting links are to be provided to avoid burning / damage of CT's in case of opening of CT terminals.

Current transformers may be multi or single-core type. All CTs shall be provided with supports independent of Bus-bar/Bus-bar supports.

The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shut down of adjacent feeders.

Selector Switches

Selector switches shall be of rotary type, with plates clearly marked to show the function and positions. The switches shall be of sturdy construction suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred.

Contacts of switches shall be spring assisted and shall be of suitable material to give a long trouble-free service.

Push Buttons

Push-buttons shall be of spring return, push-to-actuate type. Their contacts shall be rated to make, continuously carry and break 10 A at 240 V AC and 1 A (inductive) at 220 V DC.

All push-buttons shall have one normally open (1 NO.) and one normally closed (1 NC) contact, unless specified otherwise. The contact faces shall be of silver alloy.

All push-buttons shall be provided with integral plates marked with its function.

The colour of the button shall be as follows:

Green for motor Start / breaker Close.

Red for motor Stop / breaker OPENS.

All push-buttons on panels shall be located in such a way that Red push-buttons shall always be to the left of Green push-buttons.

All emergency push-buttons shall have mushroom knobs.

Indicating Lamps

Indicating lamps shall be of the panel mounting, LED type and low watt consumption. The LED lamps shall have plates marked with its function, wherever necessary.

Lamps shall have translucent lamp-covers of the following colours, as warranted by the application:

Red for R-Phase / MCCB "ON" / Contactor 'ON'

Yellow for Y-Phase

Blue for B-Phase

Green for Contactor 'OFF'

Amber for Breaker / Starter 'TRIP'

Lamp cover shall be easily replaceable from the front of the cubicle.

LED indicating lamps should be located just above the associated push-button / control switches. Red lamps shall invariable be located to the right of green lamps.

Internal Wiring, Control Terminal Blocks, Name Plate / Labels and Painting

Internal Wiring

All switchboards shall be supplied completely wired internally up to the terminals, ready to receive external cables.

All intercubicle and inter panel wiring and connections between panels of same switchboard including all bus wiring shall be provided by Contractor.

All auxiliary wiring shall be carried out with 1100 V grade, single core, stranded copper conductor, colour coded, PVC insulated wires. Conductor size shall be 1.5 mm2 (min.) for control circuit wiring & 2.5 mm2 (min.) for CT's.

PVC insulated; standard copper wires shall be used for wiring to devices mounted on

moving parts such as hinged doors. The wire bunches from the panel inside to the door shall be properly sleeved or taped.

All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and blocks.

All internal wiring terminations shall be made with solder less crimping type tinned copper lugs which shall firmly grip the conductor or an equally secure method. Similar lugs shall also be provided at both ends of component-to-component wiring. Insulating sleeves shall be provided over the exposed parts of lugs to the extent possible.

Engraved core identification ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The ferrule shall be of self-locking type. The wire identification marking shall be in accordance with IS:375.

Wiring for equipment, which are to be supplied by the Owner and for which the Contractor has to provide mounting arrangement in his panels, shall also be provided by the Contractor, up to the terminal blocks.

All connections from vertical bus bars for individual modules above 100 A shall be by Copper / Aluminum links only. The cable connections for module up to 100 A shall be selected in such a way that there will not be any melting / shorting in case of a short circuit inside the module and the cable shall have current rating to carry the let through energy of the corresponding breakers in case of a fault. For power wiring colour coded wire insulation / tapes shall be provided.

Control Terminal Blocks

Control terminal blocks shall be of 1100 Volts grade, rated for minimum 10amps and in one piece molding. It shall be complete with insulating barriers, clip-on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams.

All terminal blocks shall be suitable for terminating on each side two (2) nos. stranded copper conductors of size up to 2.5 mm2 each.

All terminals shall be numbered for identification and grouped according to the function. Engraved white-in-black labels shall be provide on the terminal blocks.

Wherever duplication of a terminal block is necessary it shall be achieved by solid bonding links.

Terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks. The minimum clearance between the first row of terminal blocks and the associated cable gland plate shall be 250 mm.

Name Plates and Labels

All Panel Boards shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation.

All name plates shall be of anodized aluminum with white engraved lettering on black background.

Painting

All sheet steel work shall be pretreated, in tanks, in accordance with IS: 6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate surfaces shall be rinsed and passivated prior to application of stoved lead oxide primer coating. After primer application, two coats of finishing synthetic enamel paint on panels shall be applied. Finishing paint on Panels shall be Powder Coated, Siemens Grey, shade RAL–7032 throughout Orange Peel Finish with Electrostatic method or as approved by the Owner's / Consultant while approving the shop drawings.

LT Switchgear:

Standard: IEC 60947 / IS 13947 amended to date.

Only approved makes of switchgears shall be used.

LT switchgears shall be provided with necessary in built over-current, and short circuit releases

Energy meter:

3-phase, 4-wire LT CT operated static energy meters (5A) (Class 0.5) with associated CT's (400/5 A, Class 0.5, 15 VA) shall be provided for each incomer to record energy consumption. Only owners approved makes of energy meter & CTs shall be used.

MULTI-FUNCTION INSTRUMENT

Multi-function instruments (for installation in the distribution cabinet's-door), shall be suitable to measure:

- current of all phases (L1, L2, L3)
- voltage of all phases (phase-neutral, phase-phase)
- active power
- apparent power
- reactive power
- power factor (cos φ)
- kWh
- kVarh

The multi-function instruments shall be equipped with an electric measuring element and a busable interface.

Further, the multi-function instruments shall be connectable to the current transformer (nA/5A), and they shall be equipped with a digital display and a keyboard for controlling. They also shall be equipped with a peak-value-memory.

Ammeters:

Moving iron spring-controlled type, flush mounted, 96 sq. mm. and 90-degree scale and clearly readable. Range 0- 400A. Only Owner's approved makes shall be used.

Voltmeters:

Moving iron spring-controlled type, flush mounted, 96 sq. mm. and 90-degree scale and clearly readable. Range 0- 500V. Only owner's approved makes shall be used.

The configuration of LT Panel shall be as per SLD and detailed design of the Contractor, subject to approved of the Authority Engineer.

8. Distribution Cabinets - Jet Fans

The jet fans shall be fed through reversible soft starter panels the soft starter shall be suitable to perform following tasks and specifications:

- adjustable launching ramp, stooping ramp, launching voltage
- adjustable current limiting
- wear-free semiconductor switches
- continuous operation
- overload-able up to 15 % at continuous operation
- including bypass-contactor

- floating contact
- LED-indications on the device for fault diagnosis and operating diagnosis

Electronic execution with operation element, serial interface for remote control and status indication; the soft starter shall be completely programmed.

Technical Data:

Motor nominal voltage	:	3 x 433 V; 50 Hz
Rated motor output	:	at least 55 kW
(Auxiliary)Supply Voltage	:	250 V AC
Degree of protection	:	at least IP 20
Number of operations per hour	:	at least 10

Mode of Operation:

The soft starter shall be used for start / run up of the jet fans. After the sequence of starting the bypass-switch shall be activated. The soft starter and the bypass-switch shall be wired in a form, so that the motor of the jet fan also can be started using the bypass-switch in case of failure or the soft starter.

9. Power Factor Correction

Static power factor correction of suitable rating shall be deployed at the 415 V bus

The power factor correction shall ensure a power factor better than cosφ = 0.95 ind.

Just low-loss, self-healing capacitors are allowed. The capacitors shall be equipped with an overpressure protection device. The capacitor losses shall not overstep the value of 0.2 W / kVar. Each capacitor shall be equipped with an according discharge device.

10. Tests

The panels shall be completely assembled, wired, and tested for operation under stimulated conditions to ensure accuracy of wiring, correctness of control scheme and proper functioning of all equipment. The LT switchboard shall be tested as per relevant standard at the factory in the presence of owner's Engineer.

The Bidder shall furnish copies of Type test certificates. Following type tests should have been carried out in certified Test laboratory during the period not exceeding 3 years from the date of opening the bid.

- short time current test
- Temperature rise test
- One minute power frequency voltage withstand test.

Following Routine Tests shall be carried out

- Mechanical operations test
- Dielectric tests.

5.2.7 Earthing System

1. INTRODUCTION

An Earthing System is a basic requirement of any electrical & electronics installation as it forms a primary line of protection for equipment and the operator. The object of an earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose of this is to ensure that, in general, all parts of apparatus other than live parts, shall be at earth potential, as well as to ensure that operators and attendants shall be at earth potential at all times. A well-designed low resistance earthing system is necessary for

dissipation of heavy fault current and electrical surge to protect the equipment & user with minimizing the downtime, service interruption and replacement cost etc.

2. SCOPE

This document covers technical specification and designing for making Earthing Layout for Road Tunnel. The specification will cover the scope of work which will includes design, supply, installation and testing of Earthing Arrangement & its Components. The material offered shall conform to relevant standard with high quality and good workmanship capable to perform continuous and satisfactory operations in the actual service conditions at site.

The specifications will consist of the details of the Earthing Grid designed with Earthing Rod i.e. Copper Bonded Steel Rods, an Earth Enhancement Compound and permanent earthing joint solutions Exothermic Weld along with the procedure for constructing the earth pit for the maintenance free earthing system to ensure that the resistance to earth is near to acceptable values (<1Ω) throughout the life without any frequent maintenance or any replacement. The earthing system to be adopted for electronics equipment should be able to save the system components which are more susceptible to damage due to surge, transient and over voltage encountered due to various reasons.

3. REFERENCES

This specification will meet the requirements of mentioned documents & also working as a reference standard:

IEEE 80:2013	IEEE guide for safety in AC Sub-Station Grounding
IEEE 837	Standard for qualifying permanent connections used in substation grounding.
IEC 62561-7	Requirements for Earthing Enhancing Compounds
IEC 62561-2	Requirements for Conductors and Earth Electrodes
UL-467	Standard for Grounding and Bonding Equipment

4. EARTHING ARRANGEMENT FOR ROAD TUNNEL

All the earthing arrangement shall be interconnected with each other. Proper equipotential bonding shall be done. The earth resistance of the whole system shall be less than 1 ohm for-

1. Portal Substations
2. External Substations
3. Internal Substations/ Niches/E&M Niches
4. Control Room Stations

5. REQUIRED PARAMETERS FOR EARTHING GRID

ERT report for the soil resistivity values and to understand type of site

1. Fault Level for which grid shall be designed.
2. Duration of fault current to get earthed
3. Availability of Earthing area
4. Duration of Fault
5. Resistivity of Surface Material
6. Material of Earth Mat Conductor
7. Earthing Mat Geometry

6. EARTHING DESIGN FOR PORTAL SUBSTATIONS, EXTERNAL SUBSTATIONS & CONTROL ROOM STATIONS

An earthing grid with a combination of horizontal & vertical conductors along with exothermic welding joints shall be designed as per the fault current requirement and

availability of area. The calculations shall be done using CDEGS software as per IEEE 80:2013. The earth resistance for the portal/external station grid shall be less than 1 ohm. Proper soil treatment is recommended in the areas of high soil resistivity using carbon based earth enhancement compound.

7. EARTHING DESIGN FOR E&M NICHES, NICHES, INTERNAL STATIONS & OTHER NICHES STATIONS INSIDE TUNNEL

An earth mat with the horizontal conductors shall be laid under the niches and the complete mat shall be interconnected with the portal/external stations earthing grid using the earthing conductor laid inside the tunnel so that the system will act as an integrated earthing system. The conductor sizing shall be done as per the fault current requirement as mentioned in IEEE 80:2013.

8. EARTHING DESIGN FOR TUNNEL BODY, S&T EQUIPMENTS INSTALLED IN THE TUNNEL

A conductor of suitable size shall be laid through the overall length of the tunnel on both the sides. At every crossing or at every 100-meter spacing (whichever is nearest) the conductor on the opposite sides shall be interconnected with each other for equi-potential bonding. Also, an equi-potential bus-bar shall be installed at every crossing, which will again connect through these conductors. All the S&T equipments and other equipments shall be connected to these bus-bars for the earthing and equi-potential bonding.

For the tunnel body earth, the civil Contractor need to leave a point at every crossing for connecting the reinforcement of the tunnel with the earthing conductor for proper equi-potential bonding and for cathodic protection.

9. EARTH GRID DESIGN

Earthing System in an Earth Grid comprises of-

1. Horizontal conductor in the form of mesh
2. Vertical Earth Pit
3. Earth Enhancement Material
4. Exothermic Welding

10. EARTH MESH: COPPER/COPPER BONDED STEEL CONDUCTORS

An earth mat shall comprise of copper or copper bonded steel round conductors. The conductor shall be suitable to achieve calculated fault current. The manufacturer shall provide the conductor sizing calculation which shall be done as per IEEE 80:2013.

Based on conductor sizing calculation, the cross section of conductor is determined and the length of the copper conductor shall depend upon the required mesh size.

11. EARTH RODS: COPPER/COPPER BONDED STEEL SOLID RODS

The earth electrode/rod is the main component of the earthing system which is in direct contact with the ground and thus provides a means of releasing or collecting any earth leakage currents. The material should have good electrical conductivity and should not corrode in a variety of soil conditions. For an effective earthing system.

Acceptable earth resistance values: The acceptance earth resistance of an earth grid (Combination of Multiple Earthing connected in parallel shall be designed as per Soil Resistivity Report) shall be <1 ohm for power components & <1 ohm for electronics component.

12. Test Certificate and Approval for Copper/Copper Bonded Steel Conductors & Rods

- The laboratory test must be in accordance with IEC 62561-2:2018.
- As per IEC 62561-2, Earth rods shall be mechanically robust to ensure correct

installation. The material of choice shall be sufficiently malleable to ensure that no cracking of the rod takes place during installation. It shall also exhibit good corrosion resistance.

13. EARTH ENHANCEMENT COMPOUND

Role/ Need of Earth Enhancement Compound:

As per IEEE 80: 2013, clause 14.5, Pg. No.- 78, "It is often impossible to achieve the desired reduction in ground resistance by adding more grid conductors or ground rods. An alternate solution is to effectively increase the diameter of the electrode by modifying the soil surrounding the electrode. Thus, the Ground Enhancement Material are typically placed around the rod in an augured hole or around grounding conductors in a trench, in either a dry form or premixed in slurry".

As per IEC 62561-7:2018, clause 4.3, Pg. No. 8, "the material of the earth enhancing compound shall be chemically inert to subsoil. It shall not pollute the environment. It shall provide a stable environment in terms of physical and chemical properties and exhibit low resistivity. The earthing enhancing compound shall not be corrosive to the earth electrode being used.

Earth enhancement material is a superior conductive material that improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It improves conductivity of the earth electrode and the ground contact area. It shall be tested and confirm to the requirements of IEC 62561-7 having the following characteristics: -

i. RoHS tested Earth Enhancement Compound tested by NABL accredited lab in compliance to IEC 62561-7 with a resistivity some with a resistivity of 0.12 ohm-m.

ii. An earth enhancing compound shall be tested for Leaching Test, Corrosion Test, and Resistivity Test & Sulphur Test as per IEC 62561-7.

iii. It shall be a carbon-based material and shall be free from bentonite and other hazardous substances. It shall be permanent and offers +25 years of life.

iv. It shall be a non-corrosive material which does not leach out any chemicals into the ground. It shall retain moisture even in high soil resistivity areas. It shall lower an earth resistance value and shall offer a constant desirable performance.

v. Shall be carbon based with min 95% of fixed carbon content premixed with corrosion resistant cement to have set properties.

vi. Shall have high conductivity, improves earth's absorbing power and humidity retention capability.

vii. Shall be suitable for installation in dry form or in a slurry form.

viii. Shall not depend on the continuous presence of water to maintain its conductivity.

ix. Shall be permanent & maintenance free and in its "set form", maintains constant earth resistance with time.

x. Shall be thermally stable between -100 C to +600 C ambient temperatures.

xi. Shall not dissolve, decompose or leach out with time.

xii. Shall not require periodic charging treatment nor replacement and maintenance.

xiii. Shall be suitable for soils of different resistivity.

xiv. Shall not pollute the soil or local water table and meets environmentally friendly requirements for landfill, shall not be explosive & shall not cause burns, irritation to eye, skin etc. In this regard "Safety Data Sheets" shall be submitted by the manufacturers.

xv. Marking: The Earth enhancement material shall be supplied in sealed, moisture proof bags. These bags shall be marked with Manufacturer's name or trade name, quantity etc.

14. Test Certificate and Approval for Earth Enhancement Compound

i. The laboratory test must be in accordance with IEC 62561-7:2018.

ii. The compound shall be tested for Leaching Test, Sulphur determination Test, Resistivity Test, and Corrosion Test.

iii. Earth enhancement compound shall be tested for ROHS Restrictions of Hazardous Substances.

iv. As per IEEE 80, the compound shall be carbon based and shall have resistivity less than 0.12 Ω-m.

15. EXOTHERMIC WELDING SYSTEM

i. Electrical jointing or connection reliability is critical to the long-term integrity of the electrical system. Over the period of time, due to ageing, less maintenance and changing weather conditions the joints are becoming low performing joints as it gets corroded or loosen due to temporary jointing techniques.

ii. Recommended by IEEE 80, BS 7430, NBC 2016, an exothermic welding system is used for making electrical connections of copper to copper, copper to steel or copper to cast iron for grounding and cathodic applications. An exothermic welded connection shall be suitable for exposure to the elements of direct burial in earth or concrete without degradation over the lifetime of the grounding system.

iii. An Exothermic Welding System complying IEEE 837, has come up as a robust solution for these problems. Today, Exothermic Welding is a globally accepted method to make reliable and safe connections between two or more conductors. This technology is highly portable and does not require any external source of heat to make a joint offering in permanent molecular bonding among metallic conductors.

iv. All the buried joints shall be exothermically welded.

v. The molecular bonding shall offer complete surface contact hence an electrolyte cannot penetrate between the conductors which provide integrity to the joints.

vi. Testing of Exothermic Welding: - The laboratory test must be in accordance with IEEE 837.

5.2.8 Distribution / Sub-Distribution Boards

1. Scope

This specification covers Design, engineering, manufacturing, testing, supply, delivery, erection, installation, testing & commissioning of triple pole and neutral out door Type, Out Door Installation, Minimum IP 54, (TPN) Distribution feeder pillar suitable for 415 v AC 3 Phase 4 wire system as per ISS: 5039 /8623/1977 with latest amendments, if any.

2. Standards

The distribution feeder pillars shall conform in all respect to the relevant Indian /International Standard specification, with latest amendments thereof; some of them are listed below.

Indian standard	Title
IS- 5039	Distribution Feeder Pillars
IS -8623/1993	Low Voltage Switch gear and Control gear assemblies
IS-13947	Degrees of protection provided by enclosures
IS-5/1961	Specification for colours for ready mixed paints
IS- 11353	Guide for uniform markings and identification of conductors and apparatus terminals
IS-6005	Code of Practice for Phosphating of iron and steel

NFPA 502	Standard for Road Tunnels, Bridges, and other limited Access Highways

Material conforming to other internationally accepted standards, which ensure equal or higher quality than the standards mentioned above would be acceptable. In case the bidders who wish to offer materials conforming to the other standards, salient points of difference between the standards adopted and the specific standards shall be clearly brought out in relevant schedule. Four copies of such standards with authentic English translation shall be furnished along with the offer.

3. Construction

Feeder Pillars shall be suitable for outdoors installing and to have maximum protection from inclement weather. It should have compact construction with a degree of Protection IP-55 in accordance with IS-13947 with latest amendments.

FP & SP shall be made out of sheet steel of minimum 2 mm thick with proper support members so as to make it robust in operation. Bidders can also offer heavy gauge fire resistant poly propylene (FRPP) enclosures of thickness not less than 4mm for body frame and 2.5 mm for door panel.

Suitable mild steel reinforcement (frame) shall be provided which shall be coated with FRPP.Then the body of box shall be casted over the steel reinforcement by suitable mould

The FRPP panel shall be rodent proof, fire retardant and UV stabilized.

4. DOORS

Double –hinged doors should be provided on front as well as on rear to enable installation and inspection of cable connections and other equipment. Three heavy duty inside hinges shall be provided per door leaves. The design shall permit the doors being completely removed when necessary.

5. LOCKS

The front and back doors should be fitted with separate 65mm size MS locks (with special keys) such that unless door is closed (both leaves) it cannot be locked and unless it is locked, key cannot be out.

6. CANOPY

It should so be sloping so that rainwater does not accumulate. The canopy should extend beyond the feeder pillar body to avoid any rainwater falling inside the pillar.

7. MOUNTING

To mount on brick cement concrete plinth. the construction of the plinth is included in the scope of work.

8. APRON

Lower part should be made of angle iron reinforcement of 50x50x6 mm frame work (coated with FRPP) of 300 mm height covered with 315mm. Thick FRPP panel on all side s and bottom.

9. ANGLE IRON STAND

The apron shall be mounted on angle iron stand. The stand should be of angle iron 75x75x6mm (coated with FRPP) to provide strong supporting structure to the shell.

10. Weather Proofing and Ventilation

The canopy shall project over the side and doors and sides shall be lower than the top of side section of the shell to avoid ingress of water.

The side section shall be folded to form a water drawing channel for easy drainage of water through the sides and not through front or back.

The angle section shall project above the sides section to provide a gap (3.0mm between the), section and canopy to facilitate ventilation.

Ventilation Louvers cell type ventilation louvers covered with welded mesh screen and filter inside section of the shell.

11. 3.8.11 Bus Bars

Bus bars should be in one piece for each phase and neutral of electricity. Aluminium of size 50x12mm, (or as per the current capacity with current density as 0.7 A/sq.mm) PVC sleeved /taped suitable with red, yellow and blue for the phase and green for neutral. All live joints shall be PVC taped. All bus bars taping and markings shall be in accordance with IS-11353. The bus bars should be mounted on insulators and fixed with riveted joints. Hylam barriers between the bus bar of each phase and between the bottommost phase and the neutral shall be provided. The bus bars should withstand thermal stress and dynamic forces in the event of short circuit and it should be supported and arranged so as to withstand any damage or deformation at specified short time current of 36KA for one second as per IS- 5039/1983 with latest amendments.

12. Circuit Ways

The configuration of Distribution/Sub-Distribution Boards shall be as per the detailed design of the Contractor, subject to approved of the Authority Engineer.

13. Earthing

Earthing shall be provided with two separate earthing terminals on its casing on either sides of the apron over and above all other means of earthing (i.e. earthing through armouring of current carrying cables).The earth terminals shall be complete with galvanized bolts, nuts and washers of size 6 x20mm.

The terminals shall be identified by means of proper sign marking in legible manner adjacent to the terminal.

One aluminium earth bus bars shall be provided with suitable holes and nuts and bolts for connecting cable armouring to earth through it. The connection shall be through cable sockets to be provided. The size of the earth bus bar shall be 250 sq. mm and material shall be electrolytic aluminium.It shall be running along the feeders pillar from one end to the other and connected to then earth terminals at the ends .

14. Pillar Lighting

A lamp holder and CFL lamp complying with IS -1258 operated by an internal piano switch a service fuse in the lamp circuit shall be fitted in each pillar for internal illumination .in addition a 3- pin 15 A plug and socket Shall Be Provided With A Switch.

15. Danger Plate

An enameled sheet danger plate of approved design shall be fixed on the front and rear doors of the pillar.

16. Iron Casings

All angle iron/reinforcement shall be coated with FRPP.

17. Tests

Verification of temperature rise limits as per IS-8623

Verification of short circuit strength at 40KA for one second as per IS - 5039/1983/3623/1977 with latest amendments.

Verification of degree of the protection as per IS -13947 with latest amendments.

ROUTINE TESTS

Feeder pillars shall be subjected to following tests as per IS.

i. Verification of dielectric properties with test voltage 2.5 KV rms for one minute between:

- Poles
- Poles and neutral
- Current carrying and non- current carrying metal parts.

ii. Insulation resistance test between poles and body should be minimum 50Mega ohm

iii. Continuity test by providing incoming 3 phase supply and checking the Power availability on the outgoing and feeder circuits.

18. Foundation For Distribution Boards

The Contractor shall submit the design of foundation of pillars for approval of client/consultant The pillar shall be mounted on brick cement concrete plinth foundation.

Finish level of foundation shall be 50 cm above ground level.

No foundation is necessary for steel tubular pole (1/6th pole length shall be buried inn the ground) but it needs muffing with cement concrete upto 100 mm below ground and 150 mm above ground.

19. Earthing of Distribution boards

The distribution feeder pillar and the service pillars shall be earthed and such earthing is a part of the scope of work. Earthing shall also conform to the provision in design criteria and the attached earthing arrangements.

5.2.9 Tunnel Lighting

The Contractor shall design, supply and install a complete lighting system of the Portal building. All luminary es, fittings and accessories shall only be proprietary type. The Contractor shall lamp in all luminaries verify the correct operation before completion. Emergency supply shall be connected to the lighting in the Portal Buildings.

The Contractor shall provide the following:

1. lighting switches.

2. Dimmers.

The Contractor shall mount luminaires on proprietary supports by means of battens, trims,

tilize, roses or packing material to suit the location. The lighting system shall tilize 2x2.8W fluorescent lighting with electronic ballasts.

1. Scope of Work, Terminal Points & Exclusions

The scope of work for the “Tunnel and Road Lighting System” and associated items covered under this specification, shall include but not limited to the items / requirements specified in the subsequent sections.

Engineering, design, manufacture, assembly, shop testing including type tests as per IEC 60529, IEC 60598, IEC 62384, IECNA LM 79, ANSI 8750 at manufacturer's works.

- Providing all labors, materials and equipment for factory testing.
- Special tools and tackles, as required, for operation and maintenance, inspection and repair of the equipment / systems offered.
- All materials supplied under this contract shall be new and unused.

Services Under Scope of Supply

- Inspection and expediting, handling, packing, forwarding, transporting to site, documentation including submission and approval of drawings.
- Engineering of all the systems covered in this specification, including preparation and submission of detailed based on codal requirement specified in IRC SP:84 2014, IRC SP:91 2011, CIE 88: 2004 and MORTH Guidelines for Tunnel and quantification of entire items

included in the scope.

Scope of supply and services of basic equipment

- This section details out the scope of supply and services for "Tunnel and Road Lighting System" with associated auxiliaries. Components and services not specifically mentioned here but necessary to complete the work in all respects, regardless of any omission in this specification or drawings, is deemed to have been included in this section.
- Submission of Lighting layout for Tunnels and Road portion covered under the complete project stretch and approval of drawings.
- Submission of inputs regarding operating philosophy, design of circuit distribution scheme and any other inputs for completion of lighting system detailed engineering.
- The design, manufacture, Factory Acceptance Test (FAT), transportation to site, Site Acceptance Test (SAT) and Supervision of Erection, testing and commissioning of the complete Lighting System for Tunnel and Road.

2. Spares

The SUPPLIER shall include the commissioning spares along with the equipment for replacement of damaged or unserviceable parts during the execution of the project at site. The SUPPLIER is expected not to fall back on the PURCHASER from their stocks (for such replacements) which are meant for two (2) years of trouble-free operation after the equipment are taken-over.

Terminal Points

- LT Power - 230 V, 1 Ph : At the terminals of light fittings

Exclusions

- Cabling
- Lighting Distribution Boards
- Installation

SPECIFIC REQUIREMENT OF ILLUMINATION SYSTEM

The luminaries shall confirm to IS 2149-1970, IS 1913-1978 and 1944-1970 (parts I and II). The luminaries shall be totally enclosed, dust and watertight, shock resistant and specially designed to house the specified lamps, electrical gear and accessories. The body shall be made of dust painted stainless steel.

- The colour of all lamps shall be Natural White 4000 K.
- The colour rendering index Ra shall be ≥ 80.
- Luminaire/system efficacy (incl Optical and driver efficacy) shall be > 124 Lm/W
- Electrical Insulation shall be Class I or Class II
- IK rating shall be IK 08
- Fittings shall be with ingress protection of IP 66.
- System Surge Protection shall be 6/10kV
- The life span shall not be less than 50,000 hours.
- Higher efficiency long life LED shall be envisaged.
- Free from UV and IR radiations.
- LED Driver Specification
- Input operating voltage shall be 200-260 V.
- Electronic control gear shall be with THD ≤ 10%.

- The power factor shall be better than 0.95.
- Power efficiency shall be greater than 85%.

Other Parameters

- Working humidity shall be 10% - 90% RH.
- Working temperature shall be between -40 to 55 Deg C.
- All light fittings shall be of waterproof and Corrosion proof.
- Fitting shall be suitable for connection to LSOH type cable
- Higher rated lamps shall be provided with aluminum heat sink body with fins for better heat dissipation.
- Epoxy powder coated aluminum channel housing shall be provided for all tube light fittings
- The mounting brackets shall be made from stainless steel and have longitudinal slots for horizontal and vertical adjustment. The minimum numbers of mounting brackets are four per luminary.
- Phase selection shall be possible at the terminal blocks without any further modification of the wiring inside the housing/luminary.
- The housing shall be suitable for mechanical cleaning.
- BIDDER shall have to select suitable light fittings to suit Tunnel Threshold Zone, Transition Zone, Interior Zone, Exit Zone, Cross passages, E&M Niches, Lay Bye and Road illumination level calculated based on codal requirement as specified in the document. Lth Values to be considered for Illumination Level calculation for tunnels.
- No light shall be directed with flow traffic to avoid shadow effect.
- Drawings & Documents to be submitted along with the bid document:
- Illumination level calculation for each Tunnel
- Layout arrangement along with type fittings for each Tunnel
- Catalogue details of offered light fittings with technical specification
- Drawings related to High Mast pole & its Junction boxes.
- Tunnel wise power consumption
- Type Test Certificates
- Quality Assurance Plan

EMERGENCY LIGHTING

Design, supply and install a complete operational emergency evacuation lighting system, tested and commissioned in accordance with IEC/ISO standards for emergency lighting. for the Portal Buildings and Central command and control Center Visual indicator lights: Provide a red indicator, readily visible when the luminaire is in itsoperating location, which indicates that the battery is being charged.

Inverter system: Provide protection of the inverter system against damage in the event of failure, removal or replacement of the lamp, while in normal operation.

Local test switches: Provide a momentary action test switch, accessible from below the ceiling, on each luminai re to temporarily disconnect the mains supply and connect the battery to the lamp.

Common test switches : Provide a common test switch on the distribution board which disconnects main supply to the luminaries and..tests for discharge performance, after testing; this switch must automatically revert to normal operating mode.

Type: Lead-acid or nickel-cadmium batteries capable of operating each lamp at its rated output continuously at least 2 hours during completion tests and 1.5 hours during subsequent tests. ·

Battery life: At least 3 years when operating under normal conditions at an ambient temperature of 25°C and subjected to charging and discharging at 6 monthly intervals.

Marking: Indelibly mark each battery with its date of manufactu re. , General: Provide an unswitched active supply to each luminaire and extt sign, originating from the test switch control panel.

VOICE/DATA CABLING AND COMMUNICATIONS SYSTEM

Design, supply and install a complete voice/data communications and cabl ing for the Portal Buildings. Provide a complete operational telecommunications cabling system, tested and commissioned in accordance with ISO/IEC standards for category 6 communications cabling systems. Provide accommodation for telecommunications cabling infrastructure complying with ISO/IEC standards. Include the following:

A) 45 RU cabinet complete with patch panels and power rails supplied from the UPS

B) Switches equal to HP or. Cisco

C) Office server (refer PMCS section for details on server)

D) Category 6 voice/data cabling to RJ45 outlets

E) Patch leads

F) Individual workstations shall be provided by the OMCS Contractor. ;

Application Class

Application class to ISO/IEC standards for calegory 6.

Conformance: Certify the design and installation for conformance with ISO/IEC standards.

System warranty: Warrant the specified communications cabling performance for a

minimum of 15 years.

Records

Record book: Provide a record book at each cross connect.

Records in pencil: Complete the records in pencil for each termination and jumper,

providing origin and destination and type of service.

Location: Secure log books in each distribution frame records holder. Identification and

labelling, and record documentation:

Cable separation

Low voltage cables: Separate telecommunications cables not enclosed in conduits or

ducts from low voltage services by at least 150 mm.

Electromagnetic interference (EMI): Provided clearance to minimise the effect of EMI

where communication cables are installed parallel and adjacent to power cables

carrying loads in excess of 200 A.

Installation

Crossover: Install cables neatly and without crossovers between cables.

Loom size: Loom cables into groups not exceeding 50 cables, and hold looms in place using reusable cable ties at least 20 mm wide. Do not exert compressive force on the cables when installing cable straps.

Cable insulation and accessories will be Low Smoke Halogen Free, in tunnel and approach areas.

Outlets

Outlets: Provide RJ45 8-way modular jacks.

Pinouts: The pinouts vary with the application. Determine required pinouts before making cable terminations.

Fly leads

General: Provide fly leads to 50°(o of the outlets installed.

Earthing

Communication earth system (CES): Provide a communications earth terminal (CET) associated with the local protective earth (PE) system adjacent to each electrical distribution board.

5.2.10 UPS Emergency Power Supply

1. General

This article covers the UPS emergency power supply of all required equipment, materials, accessories, and all labour for the complete emergency power installation.

The Uninterruptible Power Supply in Control Buildings shall feed the following system:

- All surveillance equipment
- Fire detection system
- Data transmission equipment
- Emergency Tunnel Lighting
- Control systems

2. Scope of Work

The UPS shall include the delivering of material, feeders, complete installation, commissioning, tests and equipment of the following:

- Lighting UPS at portal ends at ___ kVA(N+1) and inside tunnels at __ kVA(N+1) of virtual power over a period of 120 minutes for tunnel loads.
- Critical Power UPS at portal ends at ___ KVA(N+1) and ____ KVA(N+1) respectively and ___ kVA(N+1) inside tunnel shall provide virtual power over a period of 30 minutes.

The UPS has to be fed from the main power supply (433 / 250 V, 50 Hz) and shall supply the connected equipment via rectifier, battery and inverter.

In the event of a main power supply failure the equipment has to be fed from the battery and inverter system without any interruption.

The UPS shall be equipped inclusive bypass switch and an interface for Telecontrol System.

3. Technical Specification (Ups Components)

INVERTER BATTERY BANK

Batteries:

i. Maintenance-free NiCd (Nickel Cadmium) power batteries of voltage as required by the UPS-system.

ii. The battery capacity at the following stations shall ensure supplying the needed load for at least 60 minutes.

iii. Batteries shall be of rugged design in order to provide a heavy-duty operation of at least

10 years with low internal resistance and minimal maintenance.

iv. Allowed temperature range: 15° to 30° C

v. Interconnection Bus Bars:

vi. The bus bars shall be made of copper according to the relevant standards, mentioned herein.

vii. Suitable size to provide a minimum voltage drop

viii. PVC clad to provide protection against accidental contact.

ix. Battery Stands / Racks:

x. The batteries shall be mounted on steel racks to provide a compact arrangement, with easy installation and access for servicing.

xi. The racks shall be made of steel with electro statically deposited powder coating.

xii. The coating shall be resistant against acid, saline and highly resistant against scratching and / or impact.

xiii. All other required materials shall be highly resistant against environmental conditions as experienced in battery rooms.

xiv. An electric ventilation and climate shall ventilate the battery room. The complete air shall be changed a minimum of five to six times per hour.

RECTIFIER / CHARGER UNIT

i. This unit has to be equipped with output current limiting, whereby the maximum output current shall be limited to 125 % of the nominal output current rating.

ii. This current limit shall be adjustable from 100 % up to 125 %.

iii. Power semiconductors in the rectifier / charger unit(s) shall be fused with fast blowing fuses, so that a loss of any one-phase semiconductor shall not cause cascading failure.

iv. Each fuse shall be controlled by a fuse monitoring circuit leading to an indicator light on the UPS's control panel as well as to a common fault indication.

v. The output filter shall minimize the ripple of the current in the batteries. Under normal conditions the ripple of the current in the battery shall exceed 3% RMS.

vi. The filter shall be adequate to ensure that the DC output of each rectifier / charger shall meet the input requirements of the inverter.

vii. The UPS shall have the capability of operating the inverter directly from the rectifier with the batteries being disconnected.

viii. Quick charging equipment shall be capable of charging fully discharged batteries within six hours.

ix. Input: 433/250 VAC, 3-phase, 4 wire, 50 Hz +/- 2 %

4. Inverter Unit

Input: Output from the rectifier / charger unit (batteries).

Output: 433/250 V sinusoidal AC.

Maximum of total harmonic distortion: +/- 1 % at power factor 1 from no-load operation to full load.

50 Hz +/- 1 % at power factor 1 from no-load to full load.

Maximum dynamic Voltage deviation: +/- 5 % during power failure +/- 10 % during major load change.

Recovery to a maximum deviation of +/- 3 % within 50 ms and to +/- 1 % within 100 ms.

Total harmonic Distortion:3 % maximum

The rectifier shall be able to operate 10 minutes at 125 % overload at power factor 1 after the working temperature has been stabilized at the nominal workload.

Under normal conditions, the surrounding temperature will not exceed + 40 °C.

A self-protecting current limiting circuit shall limit the inverter output to 125 % of the rated load or respectively in case of a short circuit.

Constant synchronization of the oscillator shall define the converter frequency and its stability during stand-alone operation.

During normal operation, the inverter shall be synchronized by the main supply. In case of mains failure or frequency-deviation larger than +2 % / -1 %, the inverter shall automatically switch-over to its interior oscillator.

Upon return of main supply, resynchronization shall be started automatically. Resynchronization at full load and / or full voltage shall be achieved within 30 seconds.

The deviation from 50 Hz shall never exceed +/- 1 Hz.

The power semiconductors of the inverter shall be fused with fast blowing fuses to prevent cascading failures.

Each fuse shall be controlled by fuse monitoring circuit leading to an indicator light on the UPS's control panel as well as to a common fault indication.

5. Protective Devices and Filter Circuits

A DC (direct current) smoothing equipment shall enable the system to achieve a total harmonic distortion, which isn't larger than 3 % RMS of the output.

Protective devices shall avoid any damage or failure on the UPS caused by excessive overload, short circuits, high voltages caused by lightning activity and/or other conditions.

6. DC Circuit Breaker

The UPS shall contain a DC circuit breaker. If open, the battery shall be completely disconnected from the rectifier / charger and the inverter.

7. System Bypass Switch

The UPS system shall be by-passed automatically in case of overload. The static switch detection and transfer time shall not exceed 5 ms.

8. Static Transfer Switch

The static transfer switch shall be equipped with a manual selector switch to allow manually controlled switching between the UPS and the bypass source for maintenance and service purposes.

The static transfer switch shall be rated higher (power, respectively current) than the inverter current limiting rate and shall have a short circuit current and time rating equivalent to the fault level of the bypass source at the static transfer switch.

9. Auxiliary Equipment

- Emergency flash light with battery charger installed in the battery room.
- All facilities required for handling of acids and gasses.
- Warning notices concerning the handling of the whole UPS system in English language.
- Working instructions for UPS

Warning notices and working instructions shall be in two separate and properly indicated pockets on the inside of the UPS switchboard as well inside the battery room.

CABLING

Cable dimensioning shall be in accordance to the relevant standards and shall have a diameter that the voltage drop is not more than 10 % to the nominal voltage from the transformer to the furthest supplied electrical facility. Also the cables shall have such a diameter that, if there is a short circuit at the furthest point to the circuit breaker, the circuit breaker cuts off without the cable exceeding its rated temperature.

MAINTENANCE

The emergency power supply shall be designed for continuous reliable operation such that the "Mean-Time-Between-Failures" (MTBF) for individual modules of the UPS through the rectifier / charger unit, inverter unit and static switch etc., shall be more than 80,000 hours.

To ensure a minimum down-time, the "Mean-Time-To-Repair" (MTTR) of the emergency power supply shall not exceed 24 hours for the UPS.

The MTTR shall be the time, excluding travel time, required to diagnose the fault and restore the emergency power supply to normal working condition by means of modular replacement at the tunnel site.

The travel time must not exceed 12 hours.

5.2.11 Erection, Testing & Commissioning of Electrical Equipment

1. Scope

This section covers the procedures & recommended practices for erection and commissioning of Electrical Works at Tunnel & auxiliary equipment, accessories, associated civil works & other materials for the commissioning.

a) Indian Electricity Rules.

b) Tariff advisory committee

d) IS-6600: Code of practice for installation and maintenance of Transformers.

e) IS-3043: Code of practice for earthing

f) IS-7098: Code of practice for installation and maintenance of cross-linked polyethylene insulated PVC sheathed cables.

g) IS-2309: Code of practice for protection of building and allied structures against lightning

h) IS-732: Code of practice for electrical wiring installation

i) IS-6665: Code of practice for industrial lighting

2. Transports for Erection

The Contractor shall provide, at his own cost and expenses, all labour, plant and materials necessary for unloading and erection at site and shall be entirely responsible for its efficient and correct operations. The Contractor shall setup his own material stores for the storage of all materials maintained by their qualified store personnel.

The Contractor is responsible for all the transport facilities, loading gauges and ensure that the equipment required to be transported shall conform to these limitations. The Contractor shall also be responsible for verifying the access facilities required for the transportation.

3. Erection Work

The installation shall be carried out by an electrical Contractor holding a valid license & grade as required by the State Government. The successful bidder shall provide particulars of the license held by him (or) his Sub Contractor to the purchaser. The installation shall require approval of the Chief Electrical Inspector and it is the responsibility of the Contractor to get this approval and the purchaser shall provide necessary assistance in this connection. The Contractor shall also fully assist the purchaser in obtaining approval from any other statutory authority, if necessary, for the successful commissioning of the

township.

Any modification in the equipment or installation that may be demanded by the inspector shall be carried out by the Contractor at no additional cost to the purchaser.

In accordance with the specific installation instructions as per the manufacturer drawings or as directed by the purchaser, the successful bidder shall unload, erect, assemble, install, wire, test and commission all electrical equipments included in this contract. Equipments shall be installed in a neat workman like manner.

Erection materials, tools, tackles, crane, rigging items, testing instruments or any other machinery required for erection shall not be supplied by the purchaser. The successful bidder shall arrange for the same in a timely manner and shall not be allowed to claim for any delay or extra cost of any nature.

Consumable materials of any nature required for the erection job shall also have to be arranged by the successful bidder.

Clearing the site after completion of erection as well as regular clearance of unwanted materials from site, returning all packing material and excess material supplied by Purchaser back to Purchaser's stores shall also be covered under the scope of work. Any damage done to buildings, structures and plant (or) property belonging to the purchaser and their parties shall be made good at the Contractor’s expense.

All equipment and instruments of indoor and outdoor type shall be inscribed with number, nomenclature, Danger Boards and other instructions.

The successful bidder shall do touch up work on the surface of equipment, which are scratched and/or damaged during transportation and erection. The paint used shall match exactly with the surface being touched up.

The successful bidder shall employ skilled and semi-skilled labourers for erection & installation testing as required. All Electricians, cable jointers, wiremen, welders and others employed shall be suitably qualified possessing valid certificates / licences recognized by the competent authorities.

The successful bidder shall also furnish a list of Engineers / Supervisors and staff employed by him for erection and installation jobs, giving in brief, qualification and experience of such staff and indicating whether they hold such competency certificates / licenses to supervise the electrical installation jobs as required under Indian Electricity Rules & State Electrical Inspectorate Rules.

The successful bidder shall set up his own workshop and other facilities at the allocated place at site to undertake fabrication jobs, pipe bending, threading etc.

The successful bidder shall be responsible for recording of all readings and observations during erection, testing and commissioning, in registers or in prescribed Performa. These shall be carried out in the presence of Purchaser's representative. All such test data and records shall be duly signed by the successful bidder's Engineer and Purchaser's representative and shall be submitted to Purchaser in triplicate.

4. Equipment Erection

The Contractor shall assemble, install and connect all the equipments with all accessories including terminal clamps, with proper alignment required to complete the job and these shall be as per equipment manufacturer’s instructions. Equipments shall be erected with proper clearances from nearby walls / other equipments / beams / column etc as per statutory requirements.

The Electrical equipment shall be done by tools & tackles as recommended so that no injury is made to the equipment. The handling during erection shall be done as per best erection practices using the necessary tools & other required materials like Vanila ropes, wooden supports etc.

5. Erection of Steel Structures / Poles

The Contractor shall Supply, fabricate and carryout erection of all steel structures required to mount the equipment, gantry structures, lightning mast, any other miscellaneous supports required to complete the job with proper alignment designated on drawings duly approved by the Authority Engineer.

Structures shall be erected on foundations until atleast 14 days after placing of the concrete in foundations. All structures shall be strictly fabricated as per drawings.

The nut & bolted type structure shall be assembled & proper tension with torque ranches shall be applied as per recommended torque charts for each type & size of bolts.

The Structure shall not be welded and if required in exceptional case, proper paint shall be applied, preferably Zinc Rich Paint or Aluminum paint of proper coat shall be applied to the satisfaction.

Control interlocks shall be provided in order to prevent the inverter from being manually switched back to the essential bus (main power) without synchronization.

6. Erection of HT Cable, Auxiliary Power and Control Cable

Contractor shall transport the cable to the installation location, laying, fixing, and terminating of cables to the required satisfaction of purchaser / consultant.

Cable laid shall be neatly dressed and clamped 1050 mm deep from the FGL. For buried cables, Cable route markers shall be installed along the cable route at every 30 meter interval, at all road crossings and joint locations.

Whenever cables pass through any floor or wall, suitable manhole/cutouts shall be made. The openings shall be sealed using suitable fire resisting materials to prevent the fire spreading.

Standard cable installation tools shall be utilized for cable pulling. Maximum pull tension shall not exceed the manufacturer's recommended value. Cable grips, rollers or pulleys used shall be properly lubricated. The lubricant shall not injury the overall covering and shall not set up undesirable conditions of electrostatic stress.

Sharp bending of cables shall be avoided. The bending radius for various types of cables shall not be less than those specified by manufacturer.

Where groups of HV, LV and control cables are to be laid along the same route, suitable barriers to (physically) segregate them shall be employed.

Where cables cross roads, water, oil, gas or sewage pipes, the cables shall be laid in reinforced concrete pipes. For road crossing, the pipe for the cable shall be buried at not less than one metre depth. Cable shall be protected at all times from mechanical injury and from absorption of moisture.

Cable that are directly buried in ground at 1050 depth from the FGL. Keep Center to center distance two dimension (2D). (Refer the Road Section Drawing for Details)

Some extra length shall be kept in each cable run at a suitable point to enable one or two straight through joints to be made at a later date, if any fault occurs.

Cables shall be laid in proper sequence so as to avoid unnecessary crossing of other cables upon entering or leaving a run of tray. Cable splices shall not be permitted.

Metal sheath and armour of the cable shall be bonded to the earthing system of the station.

Each cable shall be identified with its identification number as indicated in the drawing.

Cable clamps shall be of 3mm thick galvanised M.S. spaced at every 1.5 M interval.

Suitable cable aluminium tags shall be tied at every 30mtrs and at every bend along the cable length, when the cables run in bunches in the cable tray / trench / buried, for easy identification.

7. Cable Supports and Accessories

Cables supports shall be run in concrete trenches. Cable supports shall be installed in cable trench at 750mm interval when cable tray are not used and if cable trays are provided, it shall be supported at every 1 meter interval.

Cables shall be clamped to the cable supports in both horizontal runs and vertical runs by suitable site fabricated clamps.

All cable sleeves shall be sealed at the outlet of cables from the cable trench for protection towards entry of foreign particles.

8. Erection of Lt Panel, Other Panels and DB:

All panels & boards shall be installed on finished surfaces. The correct level shall be ascertained before final grouting.

The Contractor should take utmost care in handling delicate equipments, instruments and relays. Dragging shall be avoided as far as possible. Wherever the instruments and relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned.

The Contractor shall also carry out the following: -

- Prepare a mounting base for equipment including leveling.
- The clearance on all sides of the panels shall be as per the drawing & shall comply local statutory conditions.
- Free movement of the breaker truck in each cubicle of interchangeability of breaker trucks shall be checked before final fixing of cubicles.

9. Erection of Earthing System

Contractor shall arrange for measurement of soil Resistivity at the award of contract of arranges to furnish earthing design calculation for purchaser / consultant approval. The Contractor shall submit earthing layout, equipment earthing details for approval. The entire earthing system shall be carried out inline with the specification and as per the approved drawings

The entire earthing of substation shall be carried out inline with the specification and as per the approval drawings.

10. Contractor Tools and Equipment

The Contractor shall provide all necessary tools and equipment that are required to complete the works. The Contractor shall also submit along with bid details of tools, tackles & equipments to be employed by them.

11. Field Testing & Commissioning

a. SCOPE

This part of the specification covers the guidelines for testing and commissioning at site of all outdoor and indoor electrical equipment covered in this package.

b. STANDARDS

The testing & commissioning covered by this specification shall comply with the requirements of the latest editions of Indian Standards / regulations.

The manufacturer's recommendations for testing and commissioning shall also be followed.

c. GENERAL

Tests as detailed shall be carried out in the field prior to commissioning tests to demonstrate that the equipment's performance guarantees are met, equipment are properly installed, correctly adjusted and suitable for commercial operation.

Tests shall include those specified and any other necessary to demonstrate compliance with the specification.

All testing kits / instruments used by the successful bidder shall be calibrated prior to commencement of the tests and the calibration certificate to be produced to the Engineer at site.

d. GENERAL CHECKS

The following physical checks shall be carried out on all the equipment.

- Check for physical damage
- Check for tightness of fixing bolts, nuts, clamps etc.
- Check for oil level and oil leakage.
- Check for air / hydraulic / gas pressure where ever applicable.
- Check for earth connections
- Check for cleanliness of insulators
- Check for name plate details as per specifications
- Any other physical check as recommended by equipment manufacturer / Indian Standards / Codes of practice.

Outdoor panels

- Check for proper fixing of all components as per G.A drawing and other relevant drawings.
- Check for tightness of connections.
- Check for continuity of wiring.
- Measurement of insulation resistance.
- Check for correct operation of closing and tripping devices, alarm annunciation, indications and interlocks as per relevant drawings.
- Check for meter and relay calibrations

5.2.12 FIRE DETECTION

1. GENERAL

This covers the complete fire emergency facilities (for detecting fire in and outside the tunnel, as well as equipment for firefighting), the whole automatic Fire Detection System (linear fire detection inside the main tunnel tube and sensors inside the equipment room & Niches (with E&M equipments)) including all required equipment, materials, labour and accessories. Also, all necessary accessories, required for transmission and indication of the given signal (potential free contact) at the Control Centre and Equipment Room shall be included in the scope of work.

All interface equipment which is necessary for the data-transmission to / from the Control Centre shall be included in the central connection element.

The observation of the tunnel is divided into two central units:

- Fire detection system (equipment room, Niches (with E&M equipments), substation Niches, Control Centre)
- Linear fire detection system (tunnel tube)

The whole fire detection system shall be proofed by an accredited laboratory. The Contractor shall hand over a protocol of this examination to the Client.

Any kind of fire detection equipment shall be supplied by the UPS-system.

2. SCOPE OF WORK

FIRE DETECTION SYSTEM

Fire detection unit with subunits in the tunnel tube

- With interface to linear fire detection system
- Manual alarm push button "FIRE" at the Niches (with E&M equipments) & equipment room
- Optical smoke detectors in the equipment rooms, control room (raised floor and ceilings)
- Alarm, control and indicating panel(s)
- Cabling for power supply, control, and monitoring
- Interface for corresponding automatic controls of the telecontrol system (SCADA) which distributes the command(s) to the CCTV System, the Control Centre, the Ventilation Control System, the Lighting Control System, etc.

LINEAR FIRE DETECTION SYSTEM

The linear heat sensor cable shall run through the tunnel tube and mounted on the ceiling of the tunnel tube.

The linear heat sensor cable shall be controlled by a linear heat detection unit. The detection units shall transfer the alarms to the main linear fire detection unit, and further on to the Fire alarm Control Panel in the equipment room / control room. From the Niches (with E&M equipment)/ equipment rooms / niches substation, the fire alarms shall be transmitted to SCADA.

The detection system shall measure the absolute temperature, the increase of temperature over time and shall hand over this information to the belonging linear fire detection (sub) unit. The linear fire detection system shall be able to check, if the rising of the temperature is caused by a fire, or if there may be a fault.

The linear heat detection (sub) unit shall determine the local temperature values as follows:

- Current absolute temperature.
- Increase (change) of temperature per minute.
- Temperature profile.

The time between registration of a fire alarm and activation of the necessary automatically operations shall take place within 1 minute.

The localization of fire shall be specified with an accuracy of 5 m.

Spurious / false alarms caused by temperature fluctuation shall be avoided by appropriate precautions.

The exact location of the linear heat sensor cable shall be defined by the manufacturer or the Contractor, as the exhaust temperature of the diesel locomotive can affect the detection of the cable.

LINEAR TEMPERATURE DETECTION SYSTEM/ LINER HEAT/ FIRE SENSING CABLES

- Linear Temperature detection central unit with subunits and temperature sensitive cabling
- Fire Alarm, control and indicating panel(s)
- Cabling for power supply, control and monitoring
- Interface to fire detection unit and further on transmitting of information to SCADA

3. FIRE DETECTION & ALARM SYSTEM

This section of the specifications includes the furnishing, installation, and connection of a multiprocessor controlled, intelligent fire alarm and integrated emergency voice evacuation system required to form a complete coordinated system ready for operation. The specification covers the complete fire protection System (for detecting fire in and outside the tunnel, as well as equipment for fire -fighting), the whole automatic fire detection system (linear fire detection inside the main tunnel tube and sensors inside the

Electrical Control Station) including all required equipment, and accessories. Also, all necessary accessories, required for transmission and indication of the given signal (potential free contact) at the Control Centre SCADA and niche substation / Equipment Room shall be included.

- All interface equipment which is necessary for the data-transmission to / from the Control Centre (SCADA) shall be included in the central connection element.
- The observation of the tunnel is divided into following central units:
- Fire detection system with heat/ smoke detectors (Control room)
- Linear heat detection system (tunnel tube), the whole fire detection system shall comply with standards of accredited laboratory and shall be UL listed FM approved.
- Emergency Voice/ Alarm Communication / The intelligent fire alarm and emergency voice evacuation system.
- Emergency & Service Telephone System

The whole fire detection system shall be proofed by an accredited laboratory. The Contractor shall hand over a protocol of this examination to the Client and the intelligent fire alarm system shall comply with requirements of NFPA 72 / IS-2189:2008 Standard.

Any kind of fire detection equipment shall be supplied by the UPS-system.

a. SCOPE

It shall include, but not be limited to, intelligent alarm initiating devices, alarm notification appliances, auxiliary control devices, annunciators, and wiring as shown on the drawings and specified herein.

b. TECHNICAL SPECIFICATION - DETECTION UNITS

FIRE DETECTION UNIT AND SUB UNITS

The fire detection inside the tunnel tube, as well as for automatic fire detection at the Electric Control rooms, a fully electronic system shall be provided.

All optical smoke detectors (situated in the electrical rooms) and emergency MCP's shall be controlled/connected by a common fire detection unit and Intelligent analogue addressable Fire Alarm Panel located in Control Room. Each alarm from the MCP's and sensors (of the fire extinguishers in the fire extinguisher panels) shall be detected by the associated detection (sub) units. The detection subunits shall transfer the alarms to the main fire detection unit in the Equipment Room and further to SCADA.

Electronic Hooters and one central siren shall be provided.

Every evaluated fire alarm shall cause:

- Tunnel lighting of the whole tunnel tube shall be switched on automatically. The alarm shall be transmitted to the Control Centre.
- The appropriate tunnel ventilation fire program shall start automatically.
- The firefighting water pumps shall be switched on automatically to standby but shall be used only if required.
- All necessary information shall be displayed at the Control Centre and the control panel.

For automatic operation of tunnel, the Smoke/heat Detection System / Fire Alarm Panel shall be provided with an interface, giving potential-free signals whenever a fire-detection from the various detectors occurs.

The reset of a fire alarm is only possible directly at the appropriate fire detection unit in the Electric Control rooms/ equipment room.

All devices of the fire detection system shall be supplied by the uninterruptible power supply.

c. FIRE DETECTION SYSTEM

The main purpose of automatically activating a detection system in a tunnel is to trigger an alarm upon fire detection, which is relayed to a constantly attended location in order to organize prompt emergency response, including evacuation and firefighting. Automatic fire detection systems can also be used to trigger automatic fixed fire protection systems.

Different systems may be considered, ranging from standard smoke and fire detectors (ionic, optical), flame detectors (UV/ IR), laser beam detectors (smoke) and linear detectors (conductors in insulator), to highly sophisticated early detection systems based on air sampling and CCTV imaging software.

d. FIRE SAFETY EQUIPMENT

- Automatic fire detection system in tunnel
- Fire alarm system in buildings
- Emergency telephone niches

To ensure higher system reliability, automatic fixed water-based fire-fighting systems in conjunction with Manual hose-based fire- fighting system should therefore be installed in tunnels as part of an integrated approach to the management of fire and life safety, unless it can be proved that existing early fire detection systems, combined with efficient emergency response, are enough to ensure life safety and to adequately mitigate property loss in a given tunnel. This should be considered on a case-by-case basis.

e. LINEAR FIRE DETECTION UNIT

The linear fire detection unit shall be situated at S/S (Electrical/SCADA Control Station).

A fully electronic linear fire detection unit shall continuously detect the maximum temperatures, temperature gradients over time and temperature differences over the entire cable length. Therefore, optical time domain reflection method with computer-aided alarm analysis shall be used.

The detection units shall be self-monitored. In case of breakage or malfunction an automatic fault-message shall be given to the Control Centre.

The linear fire detecting system shall be able to check, if the rising of the temperature is caused by a fire, or if there may be a fault.

The linear fire detection system shall be able to differ between hot exhaust of the moving vehicle and a “real” fire. A running or parking vehicles shall not result in a fire alarm. Only systems are allowed which have past positive test procedures in road tunnels with vehicles. The results of the test procedures shall be provided.

An unrestricted software which parts the sensor cable in zones of about 100 m length, shall be used. In event of fire alarm, so-called hot spots shall be localized.

Also, programmable alarm-thresholds per zone shall be provided. To limit the possibility of a breakdown of the linear fire detecting system, the sensor cables shall be connected at both sides to a fire detecting unit. If the sensor cable is on both endings connected to detection units, a maximum length of about 4 500 m of each sensor cable is permissible as per manufacturers recommendations.

The information of the zone which contains to the fire alarm, the direction of fire-spread / -propagation as well as the size of fire shall be transmitted to the Control Centre.

Remote adjustment and monitoring/ testing e.g. from Control Centre shall be possible.

The linear fire detection units shall include the necessary power supply unit with all required voltages with surge suppressors. A display with 4 rows (displays the messages as plaintexts) and self-monitoring shall be included in the detection units.

The linear fire detection unit shall have an automatic microprocessor unit with control panel and indicating panel. The distributor of the linear fire detection unit in the electrical rooms shall be equipped clearly, so that the display of the fire detection unit can be seen easily.

The linear fire-detection unit shall have interfaces to the fire detection unit depending on the offered system.

The fire detection & alarm system shall include following, but not be limited to, intelligent alarm initiating devices, alarm notification appliances, auxiliary control devices, annunciators, and wiring as shown on the drawings and specified herein.

- Heat detection unit with subunits in the tunnel tube with interface to linear temperature detection system/Linear Heat Sensing Cables
- Manual Call Points (MCP) in the tunnel in proximity to the Electric Control Stations, at Tunnel/ portals.
- Optical smoke detectors in the Service Electric Control Stations (raised floor and ceilings)
- Fire Alarm, control and indicating panel(s), intelligent analogue addressable type
- Cabling for power supply, control, and monitoring, FRLS
- Interface for corresponding automatic controls of the tele-control system (SCADA) which distributes the command(s) to the CCTV System, the Control Centre, the Ventilation Control System, the Lighting Control System, etc.
- Inside the tunnel emergency push buttons "FIRE" shall be mounted at Niches (with E&M equipments) and panels installed in tunnel.
- All optical smoke detectors (situated in the electrical rooms) and emergency push buttons "FIRE" shall be controlled by a common fire detection unit.
- Each alarm from the push buttons and sensors (of the fire extinguishers in the fire extinguisher cabinets) shall be detected by the associated detection (sub) units. The detection sub units shall transfer the alarms to the main fire detection unit and further to SCADA
- Every alarm shall be indicated audio-visually at the Control Centre. After verifying the alarm (true / false) by the operator by using the CCTV-System (installed by the EPC Contractor), the operator manually forwards the alarm to the fire department, to evaluated fire alarm causes:
- CCTV camera of the affected area is connected to the alarm / video screen, for surveillance the incident.
- Tunnel lighting of the whole tunnel tube is switched on automatically.
- The alarm shall be transmitted to the Control Centre.
- The appropriate tunnel ventilation fire program is started automatically.
- The fire- fighting water pumps are switched on automatically, but only if required
- All necessary information is displayed at the Control Centre and the control panel in the Control Room s.
- For automatic operation of tunnel, the designer of the Fire Detection System has to provide an interface, giving potential-free signals whenever a fire-detection from the various detectors occurs.
- The reset of a fire alarm is only possible directly at the appropriate fire detection unit in the Equipment Room, or control room.

f. EMERGENCY PUSH BUTTON "FIRE"

The emergency push buttons "FIRE" shall be installed to enable a manual fire-alarm. They shall be placed at the following locations:

- At niche with E&M equipments & portal substation
- At every S/S
- One emergency push button "FIRE" beside the entrance door to a low voltage room of the

equipment rooms, niches (with E&M equipments) & control centre.

The size of the housing of the FIRE push buttons shall be approximately 130 x 130 mm (w x h). Further on, the housing shall be made of red coloured aluminium, shall have a breakable glass front and a lockable door. The degree of protection of push buttons shall be at least IP 54.

All push-buttons bear the symbol for FIRE integrated on the housing. Also, an indication in Hindi and English shall be visible.

All push buttons shall be connected to the fire detecting loop via a coupling element. The coupling elements shall be included in the price of the push buttons.

g. FIRE DETECTORS

OPTICAL SMOKE DETECTOR

Optical smoke detectors, resistant against high humidity, shall be provided. The electronic device shall be sealed, shielded and highly resistant against electrical interference. Degree of protection: IP 43

Optical smoke detectors shall be installed:

- Detectors in Equipment room
- Detectors in raised floor in the low voltage rooms, control rooms and entrance corridors of the Electric Control Stations and Control Centre; with substructure for mounting on lower edge of the panels of raised floor.

The optical smoke detectors and the push buttons "Fire" shall be connected to the fire detection (sub) units with loops. The type of cabling depends on the used system "System-Cable".

h. POWER CABLE THERMAL MONITORING MANAGEMENT SOLUTION

DTS Power Cable Management Solution Combines All of These:

- Distributed Temperature Monitoring
- Asset Visualization
- Alarm Management
- Central Database
- Reporting & Analysis Functions
- Real Time Thermal Rating

Capabilities in one fully integrated solution package. It automatically detects hotspot locations, provides alarms if critical limits are exceeded, and produces a temperature profile report.

All data is stored in a central database and are available for reporting and analysis, see where the bottlenecks are and derive valuable information to make the best decisions regarding future power grid upgrades.

The alarm management signals when limits are exceeded and your assets are at risk. Sections of the cable route cab be flexibly defined as different zones; different alarm levels and type can be assigned to each zone.

The system offers a quick and easy overview of the thermal status of your circuit with an easy-to-use graphical user interface. Circuit layouts are mapped and the various sections are colorized according to the measured cable surface. Temperature graphs and hotspot tables are easily accessed.

i. EMERGENCY MANUAL CALL POINT (MCP)

The emergency buttons "FIRE" Manual call Points shall be installed to enable a manual fire-alarm. They shall be placed at the following locations:

One MCP in proximity to the entrance door to a low voltage room of the Electric Control Stations.

Further on, the housing shall be made of red coloured aluminium, shall have a breakable glass front and a lockable door. The degree of protection of push buttons in the tunnel tube shall be at least IP 54. In the Electric Control Stations a lower class may be used.

All MCP's shall bear the symbol for FIRE engraved on the housing. Also, an indication in Hindi, English and a local language shall be visible.

All MCP's shall be connected to the fire detecting loop via a coupling element.

j. WIRING

The transmission of data of the fire detection (sub) units runs via a single mode fibre cable (A-DF(ZN)2Y 12x12 E9/125). Only a few fibres are reserved for the Fire Detection System.

"Fire Survival armoured / unarmoured e-beam cables with annealed copper conductor having Cross linkable Low smoke zero halogen insulation / or protected with Fire Rated Glass Mica tape with low smoke zero halogen inner and outer sheath. Armoured cables should comply to BS 7846:2009 (latest edition) & unarmoured cables to BS-7629 (latest edition). Both armoured and unarmoured cables should meet fire performance circuit integrity test as per standards.

- Wiring for signal line circuits shall be 1.5 mm2 minimum and subject to the circuit load.
- Wiring for Notification Appliances circuits shall be 2.5 mm2 minimum and subject to the circuit load.
- Wiring for speaker circuits shall be 2.5 mm2 minimum and subject to the circuit load.
- Wiring for telephone circuits shall be 2.5 mm2 minimum and subject to the circuit load.

5.2.13 Integrated Tunnel Control Systems

1. General

This Specification describes the minimum standards of the Integrated Tunnel Control System (ITCS) for Tunnel Control Building & Tunnel network. The Works to be executed under the Contract include the design, development, manufacture, verification, delivery, installation, testing, commissioning (including integrated testing and commissioning) and technical support for a complete ITCS to fully integrate the control, monitoring, and supervision of Low Voltage Power & Distribution, Emergency Power Supply-DG sets and UPS, Fire Alarm System, Hydraulic System (Bore Well Pumps etc.), and other nominated Building Services Systems. The ITCS shall also interface with the requirements for control, monitoring, and supervision as required at the Tunnel Control Centre (TCC).

The ITCS is to be designed manufactured, supplied, installed, tested and commissioned by the Contractor and shall meet all performance and functional requirements as defined in the Specification. This specification contains a description of the system concepts and major components, and sections covering definitions, requirements for interfaces with other contracts, general mechanical and electrical installation design/performance requirements, and testing requirements.

The emphasis is to explain the requirements of work, interfaces with other Contractor for achieving an efficient & safe working system commensurate to the best international standards and practices. Every effort has been made to cite the design requirements very clearly, however in this contract, the Contractor shall follow acceptable standards & design procedures akin to the best adopted practices in ITCS system, wherever this is not explicitly mentioned.

2. Scope

The services to be performed by the Contractor shall include, but not be limited to, the following:

i Design, development, manufacture, verification, delivery, installation, testing, commissioning (including integrated testing and commissioning) and technical support for a complete ITCS , including all PLC/RTU Equipment, CPU's, Modules, Sub Modules, Power Supplies, Local Control Panels, PC Work Stations, Printers, Local Area Network (LAN), Ethernet Hubs and Switches, Remote Fireman's Control Panel, electrical containment and wiring systems, and other components, to fully integrate the control, monitoring, and supervision of Low Voltage Power & Distribution including Energy Metering, remote relay setting of ACBs, Diesel Generator System and strategic emergency power supply from DG sets, UPS, Lighting Control System, Fire Alarm System, Lift and Escalators, Hydraulic System (Raw Water pumps, Domestic water pumps and Fire Water pumps etc.) and other nominated Building Services Systems , as required whether or not specified , necessary to deliver the requirements of this Specification. The scope has been further given in detail as per I/O list with this document. The ITCS shall also interface with the requirements for control, monitoring, and supervision, as required at the Tunnel Operational Control Centre (TOCC). The system should be capable of independent functioning as well as seamless integration with centralized ITCS system.



ii Earthing of Programmable logic controller and Work Stations to the clean earth. Earthing drawing will be submitted to the employer's representatives for approval.

iii Integration of ITCS with other ITCS at TCC.

iv Presentations, reviews and audit support as specified in the Specification;

v Interface management as specified in the Specification;

vi System operations and maintenance support services;

vii Training for the Employer's Engineers and Training Instructors, operations staff, maintenance staff and Engineering staff;

viii Dismantling, removal and/or disposal of Temporary Works;

ix Warranty period after commissioning.

x Transfer of Technology

xi Warranty and Maintenance Support System-AMC

The list is not intended to be complete and the Contractor shall supplement it adequately for obtaining a satisfactory working ITCS System.

3. Standardization

i The Contractor shall, in establishing his design, follow the principles provided below in

the design and specification of all plant, equipment and components:

ii Similar plant and equipment shall be replaceable/interchangeable, modular in design, adaptable and extendable.

iii The technical specifications and design standards shall be uniform. Uniform standards for clear spaces, working clearances, protection of equipment and physical dimensions of equipment and interfacing with other systems.

iv Test standards and standardized equipment shall be selected or built or framed carefully, bench marked, designated and explicitly marked.

v A standard procedure shall be followed for identification of each category of equipment explicitly (suffixing or prefixing while marking and numbering for each category of equipment).

vi The operating system shall be uniform for all systems/sub systems.

vii Standards for maintenance planning shall be uniformly categorized.

viii Uniform standards shall be designated for procurement, replacement stocking and availability.

ix Equipment and accessories shall be provided with uniform standard spare capacity, protection.

x Piping, cabling etc. shall be suitably colour coded for identification and categorization for each kind of use/type. The cable terminations should be tagged and numbered as per the standards.

4. Quality control of equipment, components and material

The Contractor shall furnish the following information for each item of equipment as applicable:

i. Manufacturer.

ii. Type and model No. of equipment.

iii. Nominal capacity

iv. Power supplies i.e. Voltage & Frequency at which the equipment operates.

v. Type of Frame and foundation required for the equipment.

vi. Space requirements

vii. Controls & Protection

viii. Indications/alarm/annunciation

ix. Standards

x. Insulation class

xi. EMC Conformance and certification.

xii. Any other technical information related to the equipment.

The Contractor shall provide a list of tools and test equipment for the installation, testing and repair of any special apparatus and proposals for conducting system acceptance testing and to support the extended period of trial running.

5. Submission of Drawing & Details

i. The Contractor shall state the number and scales of all the drawings it intends to produce in support of the works under this contract. The detailed/schematic drawings to be furnished by the Contractor may include but not be limited to:

ii. Schematic drawings

iii. Interlock drawings

iv. Erection drawings

v. Wiring drawings

vi. As erected/finished drawings

vii. Any other drawings

viii. I/O Schedule and Cable Schedule

ix. A complete schedule of drawings to be produced by the Contractor shall be submitted to the Employers representative within one month (30 days), of contract award.

6. Design Considerations

a. The complete installation shall be in strict accordance with the national and local electrical codes.

i. All system components are to be designed and built to be fault tolerant:

ii. Satisfactory operation without damage at 110% and 85% of rated voltage and at +3 hertz & - 1.5 Hz variation in line frequency.

iii. Static, transient, and short circuit protection on all inputs and outputs.

iv. Communication lines protected against in-correct wiring, static transients and induced magnetic interference.

v. Bus connected devices to be a.c. coupled or equivalent, so that any single device failure will not disrupt or halt bus communication.

b. All equipment, cables and wiring shall be designed, manufactured and installed so as to secure a service life as shown below:

Control Panels	30 Years
Cables	30 Years
Tray, trunking and supports	30 Years
Sub-assemblies and components	30 Years
All other equipment	20 Years minimum

c. Switchboards, equipment, and other control components shall be rated for operation in ambient temperatures of 15 deg to 35°C and humidity up to 55 to 85% and shall have degree of protection IP- 65.

d. In the design of switchboards, local control panels, Cabinets of PLC, an allowance of 20-25% spare space capacity shall be provided for possible future expansion and all panels shall be user friendly, modular and aesthetic design, termite and vermin proof. Spare capacity of 30% shall be provided for all cable trays, trunking, wire ways, (raceways), and brackets, for future expansion.

e. Parameters for control and monitoring for the various equipment location

	PLC (Plant Room)			TCR		TCC
Functions	Condition		operation	Status	Alarm	Remote Data
Tube well pumps at station	Liquid level in the underground tank low.		Start Pump	Low water level in underground tank	Warning goes OFF when underground tank full	Warning
(1+1) – MainStandby +	Manual Switch remote	Bypass localor	Log at PLC	Red Graphics for local, grey for remote		
	Pump Running		-	Pump		

	Pump Failure	-	ON (OFF)	Standby pump fail warning	Warning
	Water level in the underground tank	If full stop Pumping Log at PLC	-	-	-
	A defined time of pumping completed	Alternating pump starts	Standby Pump is ON		
	Hours of operation	Log at PLC	-	Not run for more than a week, A Pump running for more than a defined time (Alarm)	Warning (Not Run for more than one week)
	Voltage	Log at PLC	-	No Warning Volt	-
	Pump Tripped	Log at PLC		warning	Warning
Raw water pumps at station	Liquid level in the raw water tank low		Low water level in underground tank (Raw)	Warning, goes OFF when underground tank (Raw water) full	Warning
(1+1) Main – Standby +	Maual Switch Bypass local remote or		Red Graphics forlocal,grey for remote	-	-
	Pump Running	-	Pump		
	Pump Failure	-	ON (OFF)	Standby pump fail warning	Warning
	Water level in the Underground tank	If full stop Pumping Log at PLC	-	-	-
	A defined time of pumping completed	Alternating pump starts	Standby Pump is ON		
	Hours of operation	Log at PLC	-	Not run for more than a week, A Pump running for more than a defined time (Alarm)	Warning (Not Run for more than one week)
	Voltage	Log at PLC	-	No Warning Volt	-
	Pump Tripped	Log at PLC		warning	Warning
Domestic water pumps at station	Liquid level in the Domestic water tank low	Start pump	Low water Level in Domestic water tank	Warning, goes OFF when underground tank (Raw water) full	-
(1+1) Main – Standby +	Maual Switch Bypass local remote or	Log at PLC	Red Graphics f local, grey for remote	-	-
	Pump Running	-	Pump		
	Pump Failure	-	ON (OFF)	Standby pump fail warning	Warning
	Water level in the Domestic water	If full stop Pumping	-	-	-

	tank	Log at PLC			
	A defined time of pumping completed	Alternating pump starts	Standby Pump is ON		
	Hours of operation	Log at PLC	-	Not run for more than a week,A Pump running for more than a defined time (Alarm)	Warning (Not Run for more than one week)
	PLC (Plant Room)		TCR		TCC
Functions	Condition	operation	Status	Alarm	Remote Data
	Voltage	Log at PLC	-	No Volt Warning	-
	Pump Tripped	Log at PLC		warning	Warning
Fire Fighting Pump	Hydrant Pressure fall (Major)	Start the Pump	-	warning	warning
(1+1) Main Standby+			-		
	Manual bypass local or auto		Different graphics colour for local or auto	-	-
	Pump Running	-	Pump 1/2 ON (OFF)	-	-
	Pump Failure	Start standby automatically		First Pump fail warning	Warning
	Standby pump fail	Main pump starts automatically	-	Second pump fail alarm	Alarm
	A defined time of pumping completed	Alternating pump starts	Standby Pump is ON		
	Hours operation of	Log at PLC	-	Not run for more than a week.	Warning
Jockey Pump	Hydrant Pressure fall (Minor)	Start the Pump	-	Warning	-
	Manual bypass local or auto		Different graphics colour for local or auto	-	-
	Pump Running	-	Pump ON (OFF)	-	
	Pump Failure	-		pump fail warning	Warning
	Hours operation of	Log at PLC	-	Not run for more than a week, (Alarm)	Warning
DG set	Incoming HT supply to Grid 1 & 2	Bus Couplers OFF, start	Starting DG the	Warning supply	Warning

	transformers OFF	DG set, load breaker ON	set	failed	
	Start command from control panel	Start DG set, load		-	-
	PLC (Plant Room)		TCR		TCC
Functions	Condition	operation	Status	Alarm	Remote Data
	Start command from local or remote	Breaker OFF		-	-
	DG set running		ON(OFF)		
	Incoming HT supply to ASS transformers ON	DG set OFF Bus couplers ON		-	-
	DG set failed to start or tripped			Alarm	Alarm
	Hours of operation	Log at PLC	DG set ON in casenot running more than 15 days	Not run for more than 15 days (Alarm)	Alarm
	Starter Battery Voltage	If low Log at PLC		Warning, Maintenance required	Warning
	Lube oil Level	Continuous monitoring			
	Fuel level	Continuous monitoring			
	Radiator water level	If low Log at PLC			
	Output voltage	Log at PLC	Within range, Indicate on Load	Alarm, if out of range	Out of range alarm
	Output Frequency	Log at PLC			
	Fuel Consumption	Log at PLC	Weekly report generation for fuel consumption rate vs. energy output	-	Weekly report generation for fuel consumption rate vs. energy output
	Energy Output	Log at PLC	Continuous monitoring	-	Continuous monitoring
UPS(Electrical)					
	Input Voltage	-	Continuous monitoring in decimal value		
	Battery Voltage		Continuous monitoring in decimal value		
	Charging Current		Continuous monitoring in decimal value		
	PLC (Plant Room)		TCR		TCC

Functions	Condition	operation	Status	Alarm	Remote Data
	Output Voltage		Continuous monitoring in decimal value		
	Output Frequency		Continuous monitoring in decimal value		
	Load%		Continuous monitoring in decimal value		
	Static bypass/ manual Maintenance Bypass		Different graphics Status for Various status		
	Mains failure		Alarm		
	Low battery Alarm		Alarm		
	Overload and over temperature		Alarm		
Battery Charger (ESR)					
	Input Voltage	Log at PLC	Continuous monitoring in decimal value		
	Battery Voltage	Log at PLC	Continuous monitoring in decimal value		
	Charging Current	Log at PLC	Continuous monitoring in decimal value		
	Output Voltage	Log at PLC	Continuous monitoring in decimal value		
	Mains failure		Alarm		
	Low battery Alarm		Alarm		
	Overload and over temperature		Alarm		
	PLC (Plant Room)		TCR		TCC
Functions	Condition	operation	Status	Alarm	Remote Data
	Charging/Load/Boost Charging Status		Different graphics Status for Various status		
	Static bypass/ manual Maintenance Bypass		Different graphics Status for Various status		
Entry/ Exit/ Forecourt, External	Voltage	-	ON (OFF) in defined time	No volt Alarm	Alarm

(Road) Lighting			period		
	Current	If less than 80% of nominal value in any circuit		Lamp replacements due	
	Hours of operation	Log at PLC	-	-	-
	Energy Consumption	Log at PLC	Decimal Value	-	Decimal Value
Fire Detection and Alarm System					
All zones Public Areas	Alarm Situation	Signal at FACP	-	Warning	Warning
All zones Non-Public Areas	Alarm Situation	Signal at FACP		Warning	Warning
All zones Non-Electrical Installatio ns	Alarm Situation	-	Gas Release monitoring	Warning	Warning of fire at zones and gas release
All zones Non-Hazardous Areas	Alarm Situation	Signal at FACP	-	Warning	Warning
FACP	System Fault	Fault Indication	ON	Warning	Warning
	External Fault	Fault Indication	ON	Warning	Warning
	Processor fault	Fault Indication	ON	Warning	Warning
	PLC (Plant Room)		TCR		TCC
Functions	Condition	operation	Status	Alarm	Remote Data
	Device fault/ Device isolated	Fault Indication		Warning at fixed interval	Warning
	Voltage	Log at LDC		No volt warning	-
Sprinkler	Rise in Temperature	Start Pump	ON	Warning	Warning
Hydrant	Low pressure	Start Pump	ON	Warning	
Electrical Panels					
	Manual bypass local or auto		Different graphics Colour or auto		
	DB running	-	DB ON(OFF)	Warning for No volt in EPP	Warning
	Energy Consumption	Log at PLC	Continuous monitoring in decimal value	-	Continuous monitoring in decimal value
	Voltage	Log at PLC		No volt alarm	
	Trip	Log at PLC	Red colour in	Alarm	

			graphics		
	Communication and setting of ACB Relays	Log at PLC		No volt alarm	Controland setting of ACB relays
	ControlSupply failure	Log at PLC		No volt alarm	
Lighting system					
	Manualbypass local or auto		Different graphics colour for local or auto	-	-
	Light Circuit ON/OFF Command	-	Light ON (OFF)	-	
	Light Circuit Failure	-		Circuit fail warning	Warning
	Light Circuit ON/OFF Status	-	Light ON (OFF)	No 'ON' status alarm	Warning

The workstation pc with recent configuration and operating system shall be supplied and installed in the station control room of each station. This shall be a standalone PC.

7. Programmable Logic Controller (PLC)

a. Necessary PLCs shall be installed to provide the most economic configuration based upon cost balances between PLC modularity and cabling costs, consistent with the performance requirements of this specification.

b. Location of PLCs shall be chosen such that minimum length of cable will be required between PLC and power DB.

c. PLC can be opened freely, so sufficient distance from the wall or obstruction will be maintained.

d. Cables shall be kept at a distance of 300 mm from the power cable trays/conduits at all places as entry/exit to DB, PLC etc.

e. Hubs / switches — these will be installed in separate enclosures near the, PLCs/ workstation.

f. Repeaters- these will be installed in separate enclosure at a distance of 90 meter from hub/ repeater of the communication cable to boost the signal.

g. Field sensors- sensors will be located on, or adjacent to, that equipment which is being monitored. For example, it could include sensing the electrical load, water level etc. that changes within building.

8. Facility

a. The ITCS system shall be centralized and comprise of a powerful central computer. This shall run highly sophisticated programs, which operate in 'real-time'. Workstation shall have continuous communication between the central or main operator station's central processing unit (CPU) and the remote field processing units (PLCs). The CPU is continuously updated with the conditions being monitored by, and control actions being taken by, the PLCs. It will therefore be able to implement global actions with the minimum time delay, across the whole system. However, configuration of PC and hardware components given in subsequent paras of this specification.

b. A central database management and communications system, to communicate with the PLCs and local workstations over the communications link shall be provided and to maintain a database regarding health and operation of all system points. The system should be able to log the defective sub-systems, communication failures/ breaks and also

update the data on restoration of the fault.

c. Bulk data server facilities for software back up and historical data, including equipment history of maintenance & frequent defects shall be provided at Tunnel & T.C.C. Maintain equipment history of maintenance and frequent defects. The backuphistorical data shall be available minimum for a month at a time and backup rate shall be fortnightly.

d. The ITCS should activate designated alert for the attention of operations and maintenance Tunnel passengers (for example lighting system, escalators). SMS to Mobile phones of DGM (O&M) and other designated officials of employer regarding high priority alarms, energy audit reports and specific fuel consumption of DG sets.

e. Provide clear, comprehensive displays and printed logs of equipment status to each operator workstation.

f. Provide comprehensive displays and printed logs based upon historical data, with the option of overlaying data from earlier periods.

g. Time-tag all events detected by the ITCS system, to 1 millisecond Resolution for selected high-speed inputs, and to present this information in logs as a true system- wide sequence of events.

h. Generate routine maintenance schedules automatically, based upon elapsed time and equipment operation times. Also record the maintenance activities carried out including the maintenance block taken, persons attending or having access to the plant rooms.

i. Operating systems based on a Graphical User (GUI) format incorporating the widely used WIMPs procedures (windows, icons, menus, and pointing device), where one display can overlay another shall be provided. WYSIWYG (what-you-see-is-what- you-get) display printing and print previewing features shall be provided.

The following primary facilities shall be available at each workstation:

i. Visual and Audible Alarms and event logging and printing.

ii. Operator acknowledgement of alarms.

iii. Selective display and printing of alarms and of events lists.

iv. User friendly group display on a single Screen of various E&M systems.

v. Execution of operator commands with access code security.

vi. Provision of user-friendly operator sequences.

vii. Operator entered text messages.

viii. Access to historical data files of plant status.

ix. Generation of tabular displays based upon spreadsheets.

x. Generation of graphical displays based upon mimic diagrams.

xi. Generation of printed reports and printed copies of display pages.

xii. Utilities consumption monitoring and check metering.

xiii. Operator entered data, including tagging, manually entering values and the forcing of status points.

xiv. Automatic logging of selected displays at specified times.

xv. System timekeeping.

9. Specification/requirements for hardware components

The requirements and specifications for hardware components of the PLC is as follows:

a. Components of PLC

i. PLC consists of main CPU, I/O modules, DC/DC converter and terminal blocks. It collects

data from the process, pre-processes and transmits the same, using suitable protocol (MODBUS RTU or similar), to the TCR Workstation which in turn communicates to the Central Server at the TCC via an optimized and event-based TCP/IP protocol.

ii. PLC shall be an intelligent modular, compact system that allows suitable expansion, minimum from 14 up to 1000 I/Os using the same set of basic components. The PLC shall be programmed for local control by implementing specific logic in the PLC. Input and Output modules are connected serially to make it a complete compact and modular data acquisition system. The PLC shall communicate with TCR workstation through MODBUS Protocol, using the RS232/485 port. PLC shall have a local 'intelligence' so that in the event of a breakdown in communications with the CPU, the points connected to that unit continue to be controlled according to the time schedules initially provided by the CPU.

iii. The Contractor shall ensure that the PLCs are compatible with the input/output signals from the Workstation and other Subsystems. Power supplies for interrogation of volt-free contract shall be provided as part of the PLC.

iv. PLC terminals shall be of the clamp type preferably of cage -clamp and shall be provided with isolating links

v. PLCs shall be supplied complete with 30% spare capacity for handling additional input and output signals. Expansion by at least 50% shall be possible simply by adding more I/O modules and reconfiguring the software. A further 100% expansion shall be possible by adding additional interfacing equipment in additional cabinets, etc. and reconfiguration of the software.

vi. A manual switch inside the PLC cabinet shall be provided as a hardwired facility to disable the operation of control outputs. Change of switch status shall be registered as a system event.

vii. The Contractor shall establish the I/O requirements and provide the most economic configuration of PLCs based upon cost balances between unit modularity and cabling costs for individual stations.

viii. The PLCs shall be suitable for either wall or floor mounting and shall be suitably robust for operation in Electrical switchgear room/ Pump room areas, to IEC529 IP54 enclosure standard Wall mounting is preferred. PLC shall be of the same make and type at all sites and individual components shall be interchangeable between PLCs at different sites.

ix. The PLCs shall be suitable for operating in the environment described in the General Specification clause.

x. The PLCs shall be able to be interrogated fully and be fully reconfigured from operator workstations. The Employer's personnel shall be able to re- configure fully the PLC hardware and software after completion of the training courses provided under this Contract. However, a nominated person with authorized password should have access for making such change with using proper authorization from DGM/ TUNNEL or TCC, EMPLOYER.

xi. It shall be possible to disable an individual PLC locally or from an operator workstation for servicing or reconfiguring without affecting other PLCs. When disabled or enabled, a change of status condition shall be announced on the Control Center monitor and the changed log as an event.

xii. Internal architecture of PLC

- Microprocessor base CPU
- Input and output interface modules suitable for a mixture of digital, analog and pulse inputs and outputs.
- Terminal for external cable termination
- Thermostat for temperature control

- Power indication lamps
- Document holder
- MCBs for modules, Fan, Tube lights
- Door switches
- Fuses for digital output, input and analogue input terminals
- Power supply unit

xiii. The PLC processor will have minimum Salient features as following:

- 34 KB user program memory RAMS and Flash.
- 0.4 ms/kobo bit processing
- Integrated ports: 2xMODBUS or 1xMODBUS.
- interrupt inputs and 2 cyclic tasks.
- Direct access to I/O for fast response.
- Real-time clock.
- It shall have real time clock & time resolution of the clock should be lmsec.
- PLC shall have separate battery for the above clock. PLC shall be capable of time stamping the event before communication to ITCS.
- The event scanning resolution of PLC should be of 1msec.

xiv. The PLC processor will have the capability to support the following language structures:

- Structured Text
- Sequential Function Charts
- Ladder Logic
- Function Block

The processor shall support the Advanced Instruction Set that includes basic and advanced ASCII string instructions, and advanced math functions.

The processor shall support a system protection environment with passwords and privileges and support a form of backup communications module.

xv. PLC Interface Modules

The following hardware described will interface to the field mounted sensors and equipment for control and monitoring.

Digital inputs:

12 VDC, 24 VDC, 50 VDC, 110 VDC, 110 VAC, 240 VAC (1.5 kV isolation)

Digital Outputs (relay):

Volt-free contact, 24 VDC, 30 VA Volt-free contact, 240 VAC, 125VA Analog inputs:

0-10 VDC, 0-10 mA, 4 -20 mA with electrical isolation from ground DC 12-bit resolution minimum

>60dB interference rejection at 50Hz

Analog Outputs:

0-10 VDC, 4-20mA

Pulse Inputs:

12 VDC, 24 VDC up to 10 pulses/sec (2kV isolation)

Serial Link:

RS 485, RS 232 / V24, RS422

b. PLC Hardware Requirements

PLC Operating Voltages: The PLC must be able to operate at 100% from the following power sources:

100 VAC — 250 VAC

24 VDC — 100 VDC

Note: The PLC must operate at the nominal supply frequency of 50 Hz with a 15% variation.

c. PLC Programming

i. The PLC shall be programmed with manufacturer proprietary software, IEC 1131.3-compliant, mixable and reversible List language and Ladder language. The software shall feature Windows-based editing functions and integrated online help.

ii. An original copy of the latest manufacturer's proprietary software shall be provided to EMPLOYER upon completion and handover together with all generated site-specific data.

iii. PLC should be remote programmable from TCR workstation.

d. PLC communications

Although the PLC processor specified above will have the capability of communicating directly with an ITCS system via Modbus over TCP/1P protocol. In addition to the above, the PLC shall have the capability to be monitored directly using the HTTP protocol.

I. PLC Cabinet and Panel Internal Wiring

i. PLC is compact and modular in design. All the components inside the panel are din-rail mounted. PLC cabinets will be freestanding type and will have colour matching with Electrical Panel.

ii. Control panel, switchboards and distribution boards wiring shall be clearly identified in accordance with the Definitive Design Drawings using cable core markers. Cable core markers shall read left to right or top to bottom.

iii. Wiring shall be enclosed in metal ducts or neatly loomed with nylon ties or spiral binding as required. Wiring ducts shall be filled to a maximum space factor of 50%.

iv. Where wiring is required to connect to devices mounted on doors it shall be arranged such that opening and closing of the door is not impeded whilst minimizing flexing of the wiring loom. The loom shall be effectively fixed at both ends of the door opening with insulated saddles or clamps.

v. Wire colours shall comply with the following requirements: Phase Red, Yellow, Blue

Neutral Black

AC Control Grey

DC Positive Orange

DC Negative Lilac

Earth Green with Yellow trace

vi. Terminals shall be clearly numbered, and shall be rail mounted, adequately sized to suite wiring size and provided with 20% spare rail space. The bridging of terminals shall be provided by the use of terminal bridging links as supplied by the terminal manufacturer.

vii. Control wiring shall be terminated using pre-insulated pin or spade type crimp lugs. Conductors terminating to study type terminals shall be fitted with spade type crimp lugs.

viii. A separate earth bar shall be provided for the termination of all earth wires. Only one

wire shall be connected into each termination point.

ix. Minimum conductor size shall be 1.5mm2.

x. Cable glanding plates shall be earthed directly to the control panel earth bar.

xi. Panels shall be fitted with a suitable pocket to contain circuit diagrams and other relevant Definitive Design Drawings. An "as installed" set shall be provided with the panel.

II. ITCS MAIN Server

SCADA Server shall be provided with minimum following requirement:

i. Processor - 3.2 GHZ Intel Xeon 64 Bit Processor (Latest series available) with heat sinks

ii. RAM size – DDR3/DDR4 based 2X16GB

iii. 4 GB dedicated graphics card.

iv. Hard disk- Total storage of 3TB each, with RAID-6 or suitable hard disk controller.

v. Visual Display Unit- 19-inch rack integrated LED or equivalent.

vi. Video Card- Standard Graphics controller.

vii. Multimedia with accessory- Not required.

viii. DVD R/W- Dual Drives: 16x DVD-ROM Drive + 16 x DVD+/-RW double layer write capability.

ix. EMI immunity- As per IEC 801.

x. Inbuilt Network Interface Ethernet Ports

xi. Built in dual gigabit port, Ethernet GB Lan Card

xii. USB ports- 3.0 USB (4 Nos)

xiii. Server Management software- Complete with the server management software & Tool for server diagnostics and troubleshooting, including other drivers for the server.

xiv. Accessories- Accessories Including all cables/ connectors/ Keyboard/ accessories to achieve the complete working of the system.

xv. Power Supply-Fully Redundant Power Supply & Fan Unit

xvi. Operating System- Microsoft Window server Windows server 2016/ Windows server 2019 or latest windows server

xvii. External Hard Disc- Not Required

xviii. Tape Drive – For backup Required

III. Personal Computer

i. The Standalone commercial grade Work Station shall be a personal computer (PC) based central, with a minimum feature of full 32 bit processor, features latest Intel I7 , 5th Gen processor with 3.0 GHz or higher, 8 GB RAM, 1TB Hard Disk drive, ATI/NVIDIA graphics card , DVD R/RW, Dual LAN card, 2GB Dual Video Accelerator, Dual Monitor support, 2 Nos. spare USB ports, SATA/SCASI disk drive crashworthiness, and all other miscellaneous components including communication interface RS-232/485 card (MOXA Card with minimum 8 ports) to meet the requirements and specifications. Notwithstanding the foregoing guidelines, the Work Station shall be to the latest state-of-the-art performance for similar systems and shall be operated by the use of a USB mouse (Optical) connected to the station without the need of keyboard entry. To ensure hardware quality, computer clones shall not be acceptable. The PC shall be supplied with 24" VDU, One Laser Printer and with latest operating system software.

ii. The PC shall be configured such that external media of any kind may not be loadable at Operator level, which could pose the threat of external virus infection or compromise

the operating system.

iii. The Work Station shall be complete with detached 101-keys keyboard, which includes full upper/lower case ASCII keyset, a numeric keypad, dedicated cursor control keypad, and a minimum of 30 programmable function keys.

IV. Colour Monitor

The Work Station color monitor shall be Colour monitor shall be minimum 22- inch diagonal antiglare, antistatic flat LED screen, high resolution of 1280x1024 and 16 Million colour support, on screen control support, Vertical & Horizonal viewing angle 160O, Tilt Swivel Support as per specifications etc. as required Work stations shall include all accessories needed to comply with UL requirements for listing under the appropriate standards as specified in UL864 and UL916.Further, all accessories shall be included to satisfy the local authorities having jurisdiction over the system. UL listed cards (originals preferred or photocopies) shall be provided to support the documentation that such listing is in effect.

V. Printers

The sub-Contractor shall provide printers as specified for recording alarms, operator transactions and system reports. To ensure hardware quality, printers shall be internationally branded, warranted, and technical support, spare parts and consumables should be freely available from the manufacturers authorized distributors.

VI. Laser Printer

A hard-copy multi-color graphics laser printer shall be provided for recording graphic displays and associated dynamic data. Printer shall meet minimum requirements as follows:

i. Print speed — Black: up to 20 ppm; color: up to 4 ppm

ii. First page out — 18 seconds black, 29 seconds color

iii. Resolution- 600 by 600 dpi

iv. Memory — 64 MB built-in SDRAM; expandable to 192 MB with one open memory SDRAM DIMM slot

v. Duty cycle — 30,000 pages per month

vi. Media — Media handling 125-sheet multipurpose tray 125-sheet multipurpose tray, 250-sheet input tray 2 — Letter, legal, statement, executive, No. 10 envelopes, Monarch envelopes

vii. Output — 125 sheet face down bin

viii. Types Paper (plain, letterhead, prepunched, bond, color, rough, preprinted, recycled)

ix. Glossy Media, Cover Paper, Color LaserJet Transparencies, labels, envelopes, and card stock

x. Compatibility - Interfaces Hi-Speed USB 2.0 port, IEEE 1284-B compliant parallel port

xi. Hi-Speed USB 2.0, IEEE 1284-B compliant parallel port

xii. Languages PCL 6 and Postscript level 3 emulation with automatic language switching

xiii. Font capabilities — 80 TrueType TM internal scalable PCL 6 fonts; 80 TrueType internal scalable HP postscript fonts

xiv. Client operating systems — Microsoft Windows 98, 2000, Me, XP, NT 4.0 Mac OS 9.1, X v.10.1 and later; UNIX®, Linux, and OS/2 (limited functionality) vista, Windows 7, Windows 10.

xv. Network operating systems — Microsoft Windows 98, 2000, NT 4.0 Me, XP; Mac OS 9.x, OS X Vista, Windows 7, Windows 10.

xvi. Network protocols supported — TCP/IP

VII. Network Switches, Modems, Hubs, Gateways

All modems, hubs, switches, gateways and other serial equipment to be used in the application of system networks must be of industrial grade quality to meet the following criteria:

i. Can tolerate up to -40 to 85 deg C

ii. Can tolerate 5-95% humidity

iii. Provides vibration resistance (1E68-2)

iv. Withstands power surges (IEEE-472)

v. Provide easy DIN-rail mounting

vi. Are powered directly from 230V AC/110V DC

vii. Not less than 8-port 10/100 Dual-Speed ports-up to 200Mbps

VIII. Communication

The suitable communication protocol shall be adopted for various communication links. The communication Protocol can be classified as per following requirements:

i. The communication between E&M equipment to PLC: MODBUS Protocol

ii. The communication between PLC to the TCR Workstation: MODBUS Protocol over TCP/IP.

iii. The communication between Multifunction Meters and Energy meters and their communication to PLC/Workstation: MODBUS Protocol on RS 232/485 port.

iv. The communication between Dimming Light Control Panel, Fire Alarm Control Panel, and MDB & Electrical panels, Escalator Panels/MCCBs, AMF Panel etc. to the PLC/TCR Workstation: MODBUS Protocol on RS232/485 Port.

v. Communication between TCR Workstation to TCC: TCP/IP protocol on optic fiber link through TER.

vi. Supply of the hardware essential to integrate all systems for communication link as above.

vii. The communication link between TCR workstations and the TCC shall be done using TCP/IP based protocol. All the TCR workstations and TCC shall be connected in LAN TCP/1P that is being provided at TER by the main communication Contractor.

viii. Communication software in each PLC or workstation node on the network shall enable peer-to-peer operation, such that failure of any node shall not affect other nodes on the network.

ix. The system should provide instant alarm to the operator about the communication failure.

x. The healthy operation of all PLCs shall be verified at intervals not exceeding 30 seconds. PLC failure shall be displayed on the appropriate workstations as a system alarm.

xi. In the event of a failure of the main communications system, local operation from control panel at each station shall be maintained. Updating of the central database at the TCC shall take place immediately on restoration of the communications link.

xii. Operational changes and expansion will be made without shutdown the system.

xiii. Cables

10. All types of cables used in this project shall be Armoured.

i. Cables installed between PLC and DB/Sensors shall be Fire resistant low smoke Zero Halogen (FRLSZH)

ii. Cables installed between PLC and DB/Sensors shall be not less than 1.5 sq mm copper.

iii. Ethernet cables for networking of PLCs and Workstation shall be provided.

iv. 2#3C shielded cables (communication bus) shall be provided over RS232/485.

I. Moxa card/ Router

a. For communication with RS 485 port of different panels Moxa card of minimum 8 ports/Router shall be installed with the ITCS workstation.

b. Cables installed between PLC and DB/Sensors shall be not less than 1.5 sq. mm copper.

11. Specification/Requirement for System Software

I. Software features

a) It is necessary to provide a time and date for alarms, which occur, and other significant events, including operator commands.

b) Software will allow the database (points) and operating parameters (time, temperatures, limits etc.) to be modified on-line, by the operator.

c) When a binary contact goes from open to closed, or vice versa, the 'change of state' is reported by the system.

d) Some alarms may, however, be critical and should never be locked out. It should be possible to define these alarms when they are entered into the system in such a way that it is impossible to lock them out.

e) On start-up of certain plant, it takes a finite time before stable conditions are reached and the ITCS should allow for automatic lockout of alarms for a pre-set period following start-up.

f) If, either as a result of time programming, or an operator command, several large electrical items are called to start at the same instant, this may cause overloading. ITCS shall have capability to overcome this by defining these items as 'heavy' electrical items, and introduce a delay time to prevent starting of the next load until delay time has elapsed.

g) Logging of important status information will be provided. The list of such important items shall be provided by Contractor for approval of ER.

h) This should contain, in plain language, identification of the point, status and other data, plus time, date etc.

i) It should be possible to call up logs for various 'levels'.

j) It should be possible to cancel logs under certain conditions.

k) Facility of summary logs, i.e. the ability to call for a print out, for example, of all points in alarm, all points off normal, all motors which are running, all points which are locked out, etc.

l) It should be possible to log system advisory messages, e.g. malfunctions within the management system itself, such as hardware failures, power loss, failure of a point to respond to a command, communication errors etc.

m) Operator will be allowed to define the engineering units, e.g. voltage, kWh, degrees centigrade, etc., and the ranges over which they are to be measured.

n) An alarm should be reported in case of breaking the pre-set limit of analogue points such as voltage, current etc.

o) To avoid nuisance alarm, the software should have flexibility to allow varying the differentials or introducing time lag. For example, if a space temperature alarms at 25°C high and has a 0.1°C differential, it will be constantly going in and out of alarm between 25°C and 24.9°C. It would probably just as acceptable to have a 2°C differential which would reduce the number of alarms reported considerably and furthermore, when they

did occur, would be more meaningful to the operator.

p) It should be possible to lock out analogue alarms, both by the operator and automatically, during start-up maintenance operations if nuisance alarms are to be avoided.

q) It should allow start/stop commands to be set up at precise times, with daily variations as well as allowing holiday programming.

r) The system will keep a record of how many hours a plant has been running or how long a point has been running or how long a point has been in a normal or off-normal condition.

s) Limits to be set which can be used to alert the operator to the fact that maintenance is necessary or perhaps can automatically switch from one pump to another after a present period.

t) A record of consumption of things such as litters of fuel used, kWh etc. will be kept.

u) English language for both input and output will be accepted.

v) The output information should be grouped in accordance with the make-up of the `services' systems in the station building rather than the location of the field hardware.

w) "Prompting' feature will be provided, which takes the operator through the operation step by step, prompting and teaching him as he does it.

x) Dynamic colour graphics will be used to show the schematic diagram of the system.

y) Different colours will be used to bring particular conditions to the attention of the operator. The Contractor should submit scheme in this regard for approval of Employer's representative.

z) The operator will have the facility to generate or draw his own graphics on the VDU and have a library of standard symbols available to him held in the memory of the system.

aa) Password will restrict access to certain important areas, so it is necessary to control who has access to a ITCS, at what level and through which operator devices.

bb) Number of characters of password will not be less than five. cc) Password time-out will be not more than half an hour.

cc) "Database save' feature to copy the system database onto a separate storage medium, usually a disk, will be provided.

dd) Equipment’s will run on its requirement; in the rest time it will be possible to be switched off to save the energy.

ee) HMI software- On the front Screen icons for all systems shall be shown. Healthy and unhealthy status of these systems shall be shown by dynamic colour change of these icons.

II. General

a) The PLC shall be application-software controlled, with the software assembled from proven software modules, and shall be capable of the following function and facilities:

i. Local time tagging of events.

ii. Alarm handling from discrete inputs derived parameters.

iii. Combining of digital inputs Boolean functions to give conditional outputs.

iv. The equipment shall be self-monitoring for fault conditions, and shall generate an alarm on the appropriate operator workstations in the event of a fault arising.

b) PLC- software shall be capable of being reconfigured, under password control, either locally from the portable-programming device to be supplied under the Contract, or remotely over the communications links from operator workstations.

c) Event processing shall have the following order of precedence, but shall be re-

configurable:

i. Receipt of manual commands from operator workstations, each of which shall have an assignable level of command priority.

ii. Pre-defined control sequences.

iii. High-speed alarms.

iv. Normal alarms.

v. Digital events.

vi. Clock synchronization (With the master clock at TCC).

vii. Analogue events.

III. Design and performance requirements

Equipment or systems comprising several components shall be controlled through the ITCS with suitable control regimes to achieve desired operation normally automatically but with provision for manual intervention. The automatic operation shall conform to the operational, functional and overall system needs as specified in this specification.

a. The Contractor shall prepare in clear and logical form documents describing the functions transmitted and the operations carried out at the stations control room workstation and that at TCC. The control and transmission scheme shall be submitted for the consent of the Employer or his representatives.

b. The equipment shall also have arrangements to log and record various parameters on a regular basis and store the results for at least six months.

c. The ITCS supplier/ Contractor may propose the use of a serial data link instead of voltage free contacts. In this case the physical characteristics and data transmission protocol proposed shall conform to an internationally recognized publicly available standard. If there should be a match between the ITCS supplier's proposal and the capabilities of the electrical/mechanical equipment in the field for serial data link to be adopted with the consent of the Employer. The Contractor shall interface with other electrical and mechanical equipment supplier, as per the interface matrix.

IV. Design Coordination Requirements

The Contractor shall submit a list of all design review documents for the review of the Employer's Representative.

V. Applicable Design standards

- IEC – 1131
- IEC-6206
- IRC SP; 87-2013.
- IRC SP 91.

The above specifications shall be applied in a manner altered, amended or supplemented by this specification and the latest Indian Electricity rules wherever applicable.

VI. Lightning

a. The Contractor shall ensure that all equipment's are fully protected against the effects of mains surges and direct and indirect lightning strikes. Protection such as high voltage cut outs or high current cut outs shall be applied to incoming mains power supplies and to input and output signal lines to externally located sensors, transducers, actuating equipment, etc. or to any other equipment likely to be affected.

b. Lightning protection systems shall be in accordance with BS 6651 — "Lightning Protection" or an equivalent Indian/international standard.

c. All surge suppression equipment shall be self-contained and self-resetting.

VII. Alarm

a. All alarms generated by the installation including processor alarms, power supply alarms, and control equipment alarms, shall be sustained until cleared. Alarm handling shall be implemented through the ITCS system.

b. Alarms will flash on the present Screen and be audible to the station controller; it will be messaged to the mobile phone of the station controller and other concerned EMPLOYER authorities, as decided by the Employer.

c. The Alarm shall be in a form of a hooter positioned at SCR, near to the ITCS system.

VIII. Selection of equipment's

a. The Contractor should select the equipment's, subsystems of the ITCS keeping in view the requirements given in this specification.

b. In their technical bid, the bidders should provide details of systems, its subsystem, components etc.

IX. Installation

a. It should be ensured that the noise within the communication links between the PLC and the TCR Workstation is avoided.

b. Proper installation techniques should be employed to ensure adequate quality of signals from analogue sensors (transducers) to PLCs.

c. Adequate measures shall be taken by the Contractor to mitigate potential problems confronted due to the various forms of interference.

d. A semi-rigid, shielded cabling, which is, to a certain extent, self- supporting, can be used for signal and communication wiring.

e. The Contractor shall supply and install all materials including but not limited to cable tray, brackets, and supports and execute all other works needed for supporting and routing all cabling and wiring relating to ITCS. The Contractor shall interface with Building/ Civil Contractor will make provisions in structures to accommodate the fastenings.

f. The PLCs should preferably be wall mounted. All floor mounted PLCs will be grouted in the floor, so that vibrations due to tunnel vehicle movement can be born. If the problem persists then rubber AVMs can be used.

g. Separate tray, trunking and conduits will be used by the Contractor for ITCS cabling.

h. All cables will be laid in tray, trunkings, and conduits as appropriate etc. Saddling of cables on the wall shall not be permitted.

i. Dressing of cables will be done in such a manner that all cables will be laid parallel without laying/ crossing on each other. All the cables shall be properly tagged and marked on both ends and along the cable.

j. Bunching of cables near PLC entry, Power feeder entry and anywhere not permitted.

k. All trays, trunkings and conduits will be marked with a definite colour and tray will be marked clearly as 'ITCS Control'.

l. A separate team of experienced ITCS installation engineer, Software engineer, Electrician, Unskilled persons etc. will be kept for ITCS work, for work completion as per schedule in the contract. A list of such team will be submitted to the Employer's representative one month before of the start of work.

m. Scaffold, welding machine, soldering iron and other tools/special tools &plants required for execution of works under this project shall be arranged by the Contractor.

n. Installation, testing schedule will be provided one month before start of work and weekly progress will be submitted to the Employer's representative.

o. Without complete installation, tray marking, cable tagging and dressing etc., no test will be allowed.

p. Where cables cross the track, wall or are in any part external to cable trough routes, then they shall be suitably protected through PVC conduits encased in concrete. Advantage shall be taken, in consultation with the Civil Contractor, to incorporate such additional protection into the basic construction of the concrete structures.

q. All cables except main power supply cables, entering or leaving equipment rooms and wayside apparatus boxes shall be terminated in order of their core number on combined terminal/disconnection or terminal/fuse links.

r. Each wire shall be capable of being disconnected and isolated without removing the wire itself. These links shall be easily accessible for inspection and test. Each link or terminal shall be identified with the designation of the circuit it carries.

s. All electronic equipment shall comply, as a minimum, with IEC 571 or equivalent international specification. All components used shall be purchased from suppliers complying with internationally recognized quality management and reliability certification procedures. The Contractor shall declare in his offer the specifications to which he proposes to comply.

t. Printed circuit boards shall be used to mount electronic components. The boards shall be of sufficient thickness to ensure mechanical rigidity. They shall not be the sole support for connectors, fascia panels, handles etc.

u. All components shall be identified either by carrying a manufacturer's designation or part reference number or unique value in a standard format.

v. All metal enclosures shall be provided with an earthing terminal. The Contractor shall ensure that all the equipment's are properly and adequately earthed in accordance with safety standards and its rules.

X. Testing General Requirements

There will be five type of tests-

a. Factory Acceptance test for PLC, Workstation and Printer- During the test all logics shall be demonstrated with simulator and sample PLC, Workstation and printer.

b. Installation test- After delivery of the PLC at the site, this test shall be arranged to check the physical healthiness of the hardware.

c. Functional test- This test shall be arranged -to test the functioning of PLC, workstation and printer and communication network.

d. System acceptance test- This test shall be arranged to test all automation and 1/0 list, with integration of communication network.

e. Integrated test- This test shall be arranged to test the integration of the ITCS server at TCC and all workstations of different stations.

However, indicative S.A.T document shown in this specification, but it is Contractor's responsibility to submit the separate test document for each type of test to the approval of Employer's representative. All tests shall be in sequence and on completion of previous test, next test shall be arranged. Before installation test, all QA/QC document shall be submitted to the Employer's representative for the approval.

Basic monitoring and control functions will be demonstrated on a point-by- point basis. Checking out the software features is much more difficult and many of the programs will only be proved correct or otherwise by closely monitoring the ITCS operation over an extended time period. The Contractor shall provide necessary support till the time the system is reasonably established.

A re-commission or check out of the operation of the ITCS at the end of twelve months shall be carried out.

The following requirements are intended to supplement and explain the general specification requirements without in any way limiting their application.

a. The testing philosophy for the ITCS System shall ensure that the equipment functionality is thoroughly verified and validated at the Contractor's premises before delivery and commissioning. The test methodology shall be in line with the design methodology and the two shall be developed in parallel.

b. The principle of testing shall be that, at stages throughout the work, formal tests shall be performed and recorded against written test specifications, to provide a high level of confidence to the Contractor and the Employer's Representative that subsequent stages can proceed.

c. The responsibility for specifying, conducting and recording tests shall be with the Contractor, but all aspects must be to the satisfaction of the Employer's Representative. The Employer's Representative will at his discretion witness any tests. The degree to which the Employer's Representative intervenes in the process will depend upon the level of confidence built up during the project.

d. This document does not constitute a Test Specification or Test Procedure for any part of the system; rather it sets out the stages at which tests are required and the subjects, location and purpose of each stage. Inspection of incoming goods and components, and subassembly testing, shall be undertaken by the Contractor in accordance with the procedures set out in the Contractor's own Quality Management Plan and are not described here.

XI. Responsibilities for Testing & Commissioning

a. All test documentation associated with a subsystem or system test shall be submitted for review by the Employer's Representative at least 30 days prior to the scheduled commencement of the associated test.

b. The Contractor shall revise and re-submit any documents to which the Employer's Representative has raised an objection such that all test documentation associated with any testing has achieved letter of no objection from the Employer's Representative prior to the commencement of the corresponding testing.

c. The Contractor shall successfully carry out all pre-tests according to the finalized test procedures and correct any errors prior to any (associated) witnessed acceptance tests.

d. The Contractor shall produce permanent records of all test progress and results in a formal systematic manner and submit to the Employer's Representative for his review.

e. The Contractor shall carry out all remedial work and re-testing found to be necessary in order that equipment shall pass the tests.

f. Each of the above responsibilities shall be discharged to the satisfaction of the Employer's Representative, but no objection by the Employer's Representative shall not imply any diminution of the Contractor's responsibilities.

XII. Production Testing

a. Inspection - Inspection of incoming goods and component, and subassembly tests, shall be performed in accordance with the Contractor's Quality Management Plan and shall include software production and integration testing.

b. Product Inspection - Contractor's System Integration Testing - This is the Contractor own internal and un-witnessed testing on the complete ITCS System, including all simulation programs necessary to prove the totality of functionality, prior to offering them up to the customers witnessed test(s).

XIII. Acceptance

a. The Contractor shall complete all relevant Production testing before offering any Item, Subsystem or the System as a whole for any witnessed acceptance test. All

documentation covering the results of Production tests shall be referenced in the notice of witness testing submitted by the Contractor. The acceptance test stages follow the requirements of the GS clauses of the contract.

b. All parts subject to wear, such as electromechanical peripherals, may be omitted from the tests if agreed by the Employer's Representative. The printing and recording equipment needed for conducting the test shall be run throughout the test. All refills should be supplied during the period up to final handing over.

c. Tests shall be conducted to prove the individual and integrated functioning of the system hardware and demonstrate performance in the face of various contingencies.

d. Integrated system tests shall be conducted to prove the functionality of all applications software in the context of the complete integrated system, equipment and software configuration. The Contractor shall develop system test

XIV. Training

a. The Contractor shall provide training to Employer's staff. The training should be designed for few different levels of staff viz. operator of the system and engineers/technical managers.

b. Contractor shall train the following minimum staff of EMPLOYER.

Operator staff — 30 Nos.

Engineers/ Managers- 5 Nos.

c. The Man weeks required for training of above staff shall be indicated by the ITCS Contractor in their BID.

d. Operator training will be carried out on site and at the supplier's own training school, as required.

e. Engineer/ Manager Training should concentrate on making them familiar with the capabilities of the system so they he can take full advantage of the ITCS in running station building.

f. They should be trained for system administration i.e. allocating passwords and password levels, adding points to, and deleting points from, the system, setting up management reports on energy usage, cost and efficiency for major plant items, defining load shedding priorities and so on.

XV. Input/output List (Indicative)

The ITCS system shall provide monitoring and control of the following sub systems, as specified in the respective clauses of this specification. It is the responsibility of the Contractor to interpret the entire requirements of thespecification and to provide input/output interfaces as required which may be described separately throughout this specification.

SN	I/O	Source	Event	Remarks
Analog Inputs				
1	Fire water line pressure	Jockey Pumps		THROUGH VFC
2	SCR Temp			THROUGH VFC
3	SCR Humidity			THROUGH VFC
4	TPER temp.			THROUGH VFC
5	TPER Humidity			THROUGH VFC
6	TER temp.			THROUGH VFC
7	TER humidity			THROUGH VFC
8	Lux Level			THROUGH 4-20 MA
	Electrical Panels			Energy Meter
1	Voltage-Phase 1			Through RS 485
2	Voltage – Phase 2			Through RS 485

3	Voltage – Phase 3			Through RS 485
4	Frequency			Through RS 485
5	PF-3 Phase equivalent			Through RS 485
6	Current-3 Phase equivalent			Through RS 485
7	Current - Phase 1			Through RS 485
8	Current - Phase 2			Through RS 485
9	Current - Phase 3			Through RS 485
10	Power factor 3 phaseequivalent active power			Through RS 485
11	Power factor 3 phaseequivalent Reactive Power			Through RS 485
12	Power factor 3 phaseequivalent Apparent power			Through RS 485
13	Energy 3 phase equivalentActive Energy			Through RS 485
14	Energy 3 phase equivalentApparent Energy			Through RS 485
	UPS			
15	Input Voltage			Through RS 485
16	Battery Voltage			Through RS 485
17	Charging Current			Through RS 485
18	Output Voltage			Through RS 485
19	Output Frequency			Through RS 485
20	Load %			Through RS 485
21	Bypass Voltage			Through RS 485
22	Bypass Frequency			Through RS 485
	Battery Charger (ESR)			
23	Input Voltage			Through RS 485
24	Battery Voltage			Through RS 485
25	Charging Current			Through RS 485
26	Output Voltage			Through RS 485
	Digital Input			
	DG set			
1	DG set ON			Through RS 485
2	DG set OFF			Through RS 485
3	DG set TRIP alarm			Through RS 485
4	DG room exhaust fan ON status			Through RS 485
5	DG room exhaust fan OFF Status			Through RS 485
6	DG room Fresh air fan ON Status			Through RS 485
7	DG room Fresh air fan OFF Status			Through RS 485
8	Auto/Manual switch			Through RS 485
9	Lube Oil pressure low Alarm			Through RS 485
10	Engine water temp high Alarm			Through RS 485
11	DG set Battery voltage Low alarm			Through RS 485
12	DG fuel low level			Through RS 485
13	DG fuel high level			Through RS 485
	Pumps			
14	Raw Water Pump 1 Run Status			Through Voltage free contact (VFC)
15	Raw Water Pump1 Auto/ Manual Switch Status			THROUGH VFC
16	Raw Water Pump2 Run Status			THROUGH VFC
17	Raw Water Pump2 Auto/ Manual Switch Status			THROUGH VFC
18	Domestic Water Pump 1 Run Status			THROUGH VFC
19	Domestic Water Pump1 Auto/ Manual switch Status			THROUGH VFC
20	Domestic Water Pump2 Run Status			THROUGH VFC

21	Domestic Water Pump2 Auto/ Manual switch Status			THROUGH VFC
22	Tube well Pump1 Run Status			THROUGH VFC
23	Tube well Pump1 Auto/ Manual Switch Status			THROUGH VFC
24	Tube well Pump2 Run Status			THROUGH VFC
25	Tube well Pump2 Auto/ Manual Switch Status			THROUGH VFC
26	Fire Pump 1 Run Status			THROUGH VFC
27	Fire Pump1 Auto/ Manual Switch Status			THROUGH VFC
28	Fire pump2 Run Status			THROUGH VFC
29	Fire Pump2 Auto/ Manual Switch Status			THROUGH VFC
30	Jockey Pump1 Run Status			THROUGH VFC
31	Jockey Pump1 Auto/ Manual Switch Status			THROUGH VFC
32	Domestic water tank1 25% level			THROUGH VFC
33	Domestic water tank1 50% level			THROUGH VFC
34	Domestic water tank1 75% level			THROUGH VFC
35	Domestic water tank1 100% level			THROUGH VFC
36	Domestic water tank2 25% level			THROUGH VFC
37	Domestic water tank2 50% level			THROUGH VFC
38	Domestic water tank2 75% level			THROUGH VFC
39	Domestic water tank2 100% level			THROUGH VFC
40	Flushing water tank1 25% level			THROUGH VFC
41	Flushing water tank1 50% level			THROUGH VFC
41	Flushing water tank1 75% level			THROUGH VFC
42	Flushing water tank1 100% level			THROUGH VFC
43	Flushing water tank2 25% level			THROUGH VFC
44	Flushing water tank2 50% level			THROUGH VFC
45	Flushing water tank2 75% level			THROUGH VFC
46	Flushing water tank2 100% level			THROUGH VFC
47	Fire water tank 1 25% level			THROUGH VFC
48	Fire water tank 1 50% level			THROUGH VFC
49	Fire water tank 1 75% level			THROUGH VFC
50	Fire water tank 1 100% level			THROUGH VFC
	Road Tunnel Lighting/ External Lighting			
51	Status of MCCB operating Road Lighting LDB			THROUGH VFC, Microprocessor Based Release
52	Status of Contractor operating Road Lighting LDB			THROUGH VFC, Microprocessor Based Release
53	Status of Contractor operating External Lighting			THROUGH VFC, Microprocessor Based Release
	MDB (RS485)			
54	Incomer #1 On status			THROUGH VFC, Air Circuit breaker Based Release
55	Incomer #1 OFF status			THROUGH VFC, Air Circuit breaker Based Release
56	Incomer #2 On status			THROUGH VFC, Air Circuit breaker Based Release
				THROUGH VFC,

57	Incomer #2 OFF status			Air Circuit breaker Based Release
58	Bus Coupler On Status			THROUGH VFC, Air Circuit breaker Based Release
59	Bus Coupler On Status			THROUGH VFC, Air Circuit breaker Based Release
60	Incomer #1 Shunt Trip status			THROUGH VFC, Air Circuit breaker Based Release
61	Incomer #2 Shunt Trip status			THROUGH VFC, Air Circuit breaker Based Release
62	Bus Coupler Shunt Trip status			THROUGH VFC, Air Circuit breaker Based Release
	EPP (RS485)			
63	Incoming MCCB from DG AMF Panel on Status			THROUGH VFC, Microprocessor Based Release
64	Incoming MCCB from DG AMF Panel on Status			THROUGH VFC, Microprocessor Based Release
65	Incoming MCCB from DG AMF Panel Shunt Trip Status			THROUGH VFC, Microprocessor Based Release
66	Incoming MCCB from MDB Panel On Status			THROUGH VFC, Microprocessor Based Release
67	Incoming MCCB from MDB Panel OFF Status			THROUGH VFC, Microprocessor Based Release
68	Incoming MCCB from MDB Panel Shunt Trip Status			THROUGH VFC, Microprocessor Based Release
	A/C PANEL			
69	Incoming MCCB On Status			THROUGH VFC, Microprocessor Based Release
70	Incoming MCCB OFF Status			THROUGH VFC, Microprocessor Based Release
71	Incoming MCCB Shunt Trip Status			THROUGH VFC, Microprocessor Based Release
	PA PANEL			
72	Incoming MCCB On Status			THROUGH VFC, Microprocessor Based Release
73	Incoming MCCB OFF Status			THROUGH VFC, Microprocessor Based Release
74	Incoming MCCB Shunt Trip Status			THROUGH VFC, Microprocessor Based Release

	FWP PANEL			
78	Incoming MCCB On Status			THROUGH VFC, Microprocessor Based Release
79	Incoming MCCB OFF Status			THROUGH VFC, Microprocessor Based Release
80	Incoming MCCB Shunt Trip Status			THROUGH VFC, Microprocessor Based Release
	WPP PANEL			
81	Incoming MCCB On Status			THROUGH VFC, Microprocessor Based Release
82	Incoming MCCB OFF Status			THROUGH VFC, Microprocessor Based Release
83	Incoming MCCB Shunt Trip Status			THROUGH VFC, Microprocessor Based Release
	UPS			
84	Main failure alarm			THROUGH RS 485
85	No load			THROUGH RS 485
86	Low battery alarm			THROUGH RS 485
87	System fault			THROUGH RS 485
88	Overload			THROUGH RS 485
89	Over temperature			THROUGH RS 485
90	Bypass mode for Inverter			THROUGH RS 485
91	Mains ON			THROUGH RS 485
92	Mains faulty			THROUGH RS 485
93	Inverter ON/OFF			THROUGH RS 485
94	Inverter faulty			THROUGH RS 485
95	Bypass mode for battery			THROUGH RS 485
	Battery Charger (ESR)			
96	Mains ON			THROUGH RS 485
97	Charging/ discharging/boost charging status			THROUGH RS 485
98	Battery low status			THROUGH RS 485
99	Mains failure alarm			THROUGH RS 485
100	Low battery alarm			THROUGH RS 485
101	Overload and over temperature alarm			THROUGH RS 485
	Digital Output			
	Pump			
1	Raw Water Pump1 Start			THROUGH VFC, Microprocessor Based Release
2	Raw Water Pump1 Stop			THROUGH VFC, Microprocessor Based Release
3	Raw Water Pump2 Start			THROUGH VFC, Microprocessor Based Release
4	Raw Water Pump2 Stop			THROUGH VFC, Microprocessor Based Release

5	Domestic Water Pump 1 Start			THROUGH VFC, Microprocessor Based Release
6	Domestic Water Pump 1 Stop			THROUGH VFC, Microprocessor Based Release
7	Domestic Water Pump 2 Start			THROUGH VFC, Microprocessor Based Release
8	Domestic Water Pump 2 Stop			THROUGH VFC, Microprocessor Based Release
9	Tube well Pump1 Start			THROUGH VFC, Microprocessor Based Release
10	Tube well Pump1 Stop			THROUGH VFC, Microprocessor Based Release
	DG SET			
11	DG start			THROUGH RS 485
12	DG stop			THROUGH RS 485
	ESPP/A/CP			
13	Incomer ON			THROUGH VFC, Microprocessor Based Release
14	Incomer OFF			THROUGH VFC, Microprocessor Based Release

XVI. Automation

a) When water level becomes lower than a predefined mark, pump will startto fill it.

b) When water level reaches to up-to-mark, pump will stop.

c) Fire water level will not be less than 90%, at such situation Tube well pump will start and alarm will be generated.

d) If main water supply pump fails, then standby pump shall be started automatically.

e) Based on the detailed design, the Contractor shall develop a detailed ITCS input/output point list for all equipment's to be monitored and/or controlled subject to the approval of the Employer's Representative.

f) Control and monitoring shall be provided primarily at the TCR. It shall be possible, however, to enable secondary control and monitoring of equipment's from TCC

g) Description of basic functions is given in Table below:

	Functions	
Category	**Specified Categories**	**Description**
Monitor and Supervision	CRT- based supervision	Window functions are available, enabling display of plural supervisory Screen at thesame time.
	1) Status display of units	Displaying position symbol of units withthe shape, color, flickering
	2) Fault Display	Displaying position symbol of units withthe shape, color, flickering
	3) Telemetry value display	Display major telemetry values of voltage,current etc.
	4) Ready for command	Graphics colour will be yellow
	5) Running status	Graphics colour for green

	6) High/Low limit check	Supervision and display of deviation of voltage, current and such telemetry data from High/Low setting values.
	7) Trip	Trip status of the breaker will be shown byspecific color (Red)
Control	Local	No control from ITCS workstation, graphics colour will become Red
	Remote/Auto	Workstation control available, Graphics colour becomes yellow. In auto state controlled by predefined logic.
Record and Reporting	1) Reporting management	Automatic collection of various achievement data for editing and listing of operational achievement documents.
	a) Daily Report	Reporting and printing out a daily report of data arising from hourly telemeter and incidence occurrence
	b) Monthly Report	Reporting and printing out a monthly report of data arising from daily report
	c) Annual Report	Reporting and printing out an annual report of data arising from Monthly report
Record and Reporting	2) Message summary record	Reporting and printing out a message list, supported by sorting and editing functions based on specific factors, such as time and facilities.
	a) Message list Record	Reporting the contents of equipment operation status change and alarming
	b) Memo recording Screen	Reporting the contents of equipment operation status change and alarming
	Functions	
Category	**Specified Categories**	**Description**
Other Functions	1) Change over remote control to manualcontrol and vice versa	Security protection by log-on password checks (operators, system managers,programmers)
	2) Right of operation supervision and setting. a) Security Protection b) Operation Privilege setting	Setting up the scope of right-of –operationwith a user name to cover supervisory control objectives.

Note: All software needed for proper functioning/operation shall be supplied by the Contractor with adequate license and if any supplied software goes defunct by any way,the same shall be restored by the Contractor during defect liability period free of cost.All software to be supplied shall be latest version at the time of tender.

5.2.14 Closed Circuit Television System

1. General

The tunnels shall have CCTV cameras for continuous monitoring on the vehicular movement which will be linked to central control system. Camera shall be IP type. The CCTV will provide also support to early detect a fire inside the tunnel and to verify alarms coming from the automatic fire detection systems. CCTV system shall be provided with image analysis function to detect incidents (Video Incidents Detection System), wrong-way driving, car stopped or other anomalous conditions. The portals and external areas will be equipped with minimum two sets of dome dynamic colour video camera. Inside the tunnel sets of zoom dynamic auto iris colour video cameras shall be installed with a regular distance of (minimum) 150 meters. A detailed study of coverage shall be

provided by the Contractor in order to have full coverage inside the main tunnel and the most critical area (layby, cross passages etc.). Considering the importance of data and to store large amount of data securely, Network Video Recorder system shall be provided.

The CCTV System allows the tunnel operator a surveillance of the situation and the conditions inside the tunnel and at the free field areas. Thus, the operator is able to recognize abnormal conditions and can inform the people in the tunnel via the Public Address System.

CCTV cameras shall be installed within the tunnel tube and outside the tunnel:

- Inside the main tunnel tube: fixed cameras
- In front of the main tunnel portals: fixed outside cameras.
- The outside cameras shall be mounted on a column at a height of 5 m.
- In front of the portals of the Accesses: outside Dome Cameras

The outside cameras shall be mounted on a column at a height of 5 m. The direction orders shall be controlled from the Control Centre or Equipment Room (Control Panel).

The video signals shall be transmitted via multiplexers to the equipment Room / Control Room and further via optical fiber cables to the tele control system (SCADA). Between the cameras and the multiplexer Ethernet cable shall be provided. Optical fibre cable cores shall have a wavelength of 1310 to 1550 nm. At the equipment Room / Control Room the signals shall be presented/prepared and demultiplexed.

Generally, all pictures shall be available at the Control Centre.

In the Control Centre, the provided CCTV-screens (e.g. 5 pieces.) shall be available for supervising the tunnel inclusive portal areas/ etc. Five of the CCTV-screens shall show fixed pictures of the tunnel (about every 1000 m), the main portals and the access portals. The no. of screens shall be finalized by EPC / EM Contractor as per final design to suit site requirements.

One of the provided screens shall be defined as emergency screen. The emergency screen shall show the emergency / alarm image, which shall be switched on automatically if an incident occurs, therefore a separate output of the CCTV-picture switchboard shall be available, where the emergency / alarm screen shall be connected.

The other screens shall be freely selectable showing any chosen picture. So every picture shall be available on every screen to make all pictures / screen combinations selectable and re-programmable from the local CCTV Control Panel, manually.

At the equipment Room / Control Room and also CCTV-screens (alarm screens) shall be provided.

There shall be a digital video recording unit at the Control Room which records all camera pictures continuously and stores (records) the signal of the camera activated under alarm condition automatically (emergency / alarm picture).

With the aid of the colour CCTV System, the operator(s) at the Control Centre shall have clear, intelligible visual information of the tunnel.

The quality of pictures displayed on the screens shall permit the recognition of person's activity (e.g. repair work, running persons, etc.) clearly at any point within the tunnel.

The cameras (and screens) shall be of solid state-type, modular components shall be employed where practical and the circuitry shall be assembled in such a way that instructed staff can replace defective modules easily.

AII equipment shall be protected from damage by lightning surges and over voltages. An intelligent video control system shall be provided.

The interface between the CCTV-System and the Tunnel Control System is the video switch port, and prevent system faults from causing a deterioration of the monitoring

functionality, the whole system shall be designed to have a high degree of availability.

Anywhere in the CCTV System a failure or a malfunction occurs, this must not have any defects / repercussions to any other parts of the CCTV System.

The CCTV System described in these specifications shall meet the following minimum performance standards.

2. Scope Of Work

The CCTV system for tunnel shall have outdoor fixed box cameras installed at every 150m interval along the entire length of the tunnel. There shall be 2 HD outdoor PTZ cameras at both portals of the tunnel.

The CCTV system shall have a Video Management Software with redundant Management Servers. The primary management server shall be installed at Control station -1 and Backup management server shall be placed at Control station - 2 to provide HOT redundancy at management server level between Control station -1 and Control station - 2. There shall be multiple recording servers at Control station -1, each recording server capable of handling suitable cameras. All cameras shall be configured to provide live view at 1080p, 25fps with H. 264 compression. All cameras shall be recorded for minimum 30 days 24x7 at 1080p, 25fps with H.264 compression. All recordings shall be done inside the Control station.

Control station - 2 shall act as disaster recover (DR) site of Control station -1. Control station -2 will have Backup management server, three recording servers and storage for 30 days similar to Control station -1. The second video stream at 1080p, 25fps with H.264 compression for all cameras shall be configured in three recording servers at Control station -2. All cameras shall be recorded for minimum 30 days at Control station -2 and the recordings shall be used in case of failure of Control station -1. When there is no motion in the field of view of the camera, the recordings shall happen at 1080p, 5fps with H.264 compression. In case of motion is detected by the camera, recordings shall happen at 1080p, 25fps with H.264 compression. The system shall have pre-recorded and post record feature configurable for each camera from 5 sec to 60 sec. All secondary recordings shall be done inside the Control station.

All cameras inside the tunnel shall have IR of 100m illumination range to cover entire tunnel.

Video analytics shall be configured on the cameras inside the tunnel. Software based Video Analytics shall be preferred. There shall be additional servers for Video Analytics. The EM Contractor shall provide full compliance on technical specification of VMS and cameras as given below:

- CCTV Cameras
- Camera distribution boxes
- Multiplexers / Demultiplexers
- Video Switch
- Video amplifier
- CCTV picture switchboard at Control Room
- CCTV control panel at the Control Centre
- CCTV screens at the Control Centre
- Video recording unit
- Video detection unit
- Cabling
- Camera Column

3. Technical Specifications-CCTV Cameras

The camera shall be a colour CMOS type. It shall be capable of operating under a wide range of lighting conditions, varying from brilliant sunshine to night-time with minimal lighting.

Each camera shall allow any alphanumeric insert text into the picture. The text shall consist of at least 10 digits, adjustable by at least two buttons. Each digit can be a number or letter, which shall define the position of the camera for example by km - chainage.

Each IP based fixed camera unit shall consist of a CCTV camera, camera housing with a mounting bracket and a heating unit. The dome camera in the free field area shall be vandal-proof camera with pan/ tilt and zoom function.

4. Video Management System

The Video Management System (VMS) shall be a scalable Microsoft Windows-based video management and surveillance system consisting of four primary components, as follows:

- A core server application to maintain the database of cameras and recording devices and to provide a web-based administrative portal to manage the video surveillance system
- A media gateway application to route video traffic to users as requested and appropriate
- A client presentation application to allow users to view and manage live and recorded video.
- A storage management application server to manage the video storage resources on the network.

SYSTEM FUNCTIONS AND CAPABILITIES

The VMS shall be designed for reliability through fault-tolerant, distributed architecture, and multiple levels of redundancy.

The VMS shall provide an open interface that facilitates the creation and deployment of user interface plug-ins including mapping, video information overlays, access control, and license plate recognition.

VIDEO CAPABILITIES

Support recording of MJPEG, MPEG-4 and H.264 IP video streams

Support megapixel video cameras up to 28 Megapixel resolution

Support for ONVIF S and G profiles

Aggregate independent VMS deployments across multiple networks and manage all video through a single system while preserving local operation.

Analytic capabilities integral to VMS

- Motion - Detection of objects that move within, enter, or exit a scene and triggering an event
- Alarm - Detection of physical alarms from cameras within the system, triggering an event
- Each VMS component shall operate on standard commercial off-the-shelf (COTS) hardware.
- VMS software updates shall be downloadable from a publicly available website.
- The VMS shall indicate system performance and operation status utilizing a variety of reports including csv and pdf formats.

The Manufacturer shall offer a mobile application with the capability to access live video from up to 500 cameras.

CORE SERVER APPLICATION

The core server application shall have central management responsibility, with the following functions and characteristics:

- Maintain a database of cameras and recording devices
- Provide an administrative Web interface
- Define and administer level user accounts, their associated roles, and permissions for the system functions and devices users can access
- Provide basic access to video streaming resources, ensuring that users with appropriate permissions can view video from the system without installed video client software
- Continually search the network for relevant devices
- Assign resources to video recording pools
- Store videos that operators elect to export from network storage devices for safe keeping, supporting the storage of video clips relevant to an investigation independent of standard recording devices
- Create and assign "tags" to efficiently organize cameras and devices within the system
- Configure and respond to events within the system
- Download reports from the system in csv format contained within a ZIP archive
- Perform daily backup at a specified time

DEPLOYMENT OPTIONS:

Independent core server working with an independent media gateway application server to provide systems functions

- combined single server also hosting the media gateway application
- distributed cluster to provide fault tolerance, scalability and load balancing
- virtual machine

5. Hardware Requirements

- Processor: Intel i-3, i-5 or latest
- Operating System: Microsoft Windows 2012 Server / Windows 8/10 or latest
- RAM: 32 GB DDR RAM ECC
- SSD Storage: 480 GB
- HDD: 2 TB
- Video
- Graphics: Intel HD Graphics P47400
- Outputs:
- Display Port (2)
- DVI-D
- VGA
- Resolution Capability:
- Display Port: 3840 x 2160 @ 60 HZ
- DVI-D, VGA: 1920 x 1200 @ 60 HZ

MEDIA GATEWAY APPLICATION

Based on a successful determination by the core server application of a user's permissions, the media gateway connects the user with the appropriate camera, encoder, or recorder device.

The media gateway shall be deployed within the VMS in modular fashion to allow expansion

of system capabilities or to build redundancies within the system to maximize video availability.

DEPLOYMENT OPTIONS:

- Independent core server working with an independent core server application to provide systems functions
- combined single server also hosting the core server application
- virtual machine

CLIENT APPLICATION

The Client application shall be Windows-based, providing an environment from which authorized users can watch live and recorded video on a computer in which the application has been installed.

The Client shall be comprised of a main control panel, which may be hidden, working in unison with a series of windows (workspaces), each providing a tab-based experience.

WORKSPACES AND TABS

- The Client interface shall be based upon workspaces and tabs.
- A tab shall be a configurable layout populated with sources of content and plug-ins contained in cells.
- A collection of one or more tabs shall constitute a workspace.
- The Client shall allow configuration and recall of complete workspaces.
- An operator with appropriate permissions shall be able to send a saved workspace to other clients, causing their system to launch the saved workspace.
- Any layout of video can be saved as tab to be later recalled by an operator.

An operator with appropriate permissions shall be able to send a saved tab to other clients, causing their system to launch the saved tab.

Cells shall have the capability for system management, live view, and playback search options.

Remote Tab Push: an operator with appropriate permissions can choose to send a saved tab one or more operators' clients, causing their system to launch the saved tab.

6. Live View and Playback

A list of video and audio sources which users are authorized to access shall be displayed.

The client computer shall be able to connect to an unlimited number of recorders simultaneously to display live and recorded video.

The client shall allow video streams to be selectable from a system tree on an individual camera, individual system, client defined local groups, or from pre-defined recorder-based groups.

Users shall be able to seamlessly switch between live and recorded video on the fly.

LIVE VIEW

For live view, cells 1/4 the size of the tab or larger will use the primary stream from a video source, and cells smaller than 1/4 the size the tab shall use the secondary video stream.

7. Pan Tilt Zoom (Ptz)

Digital Zoom - An operator shall be able to digitally zoom in a video stream in live or playback mode.

Optical Zoom and Pan Tilt Control: Operators shall be able to use a mouse or joystick to control PTZ cameras.

PLAYBACK

The Client application shall enable simultaneous playback for up to (9) synchronized cameras.

The Client application shall have the capability to playback non-synchronized cameras at one time in different cells.

For viewing recorded video, cells 1/4 the size of the tab or larger shall display full-frame rate video, and cells smaller than 1/4 the size of the tab shall playback only I-Frames to conserve bandwidth and processing power.

When hovering over a recorded video time bar, an operator shall see a thumbnail representing the contents of the video stream at that point in time.

Available playback control functions:

- date-time selection
- synchronized playback of selected cells within a tab
- play video at normal speed
- pause video and advance one frame
- pause video and rewind one frame
- fast forward video at speeds up to 16x
- rewind video at speeds up to 16x
- rewinds video 30 seconds and initiates playback
- forward video to live playback
- take snapshot of the current frame

Hovering over a video playback cell with a mouse shall display the playback control menu.

INVESTIGATIONS

An investigation mode shall be available to provide a 2 x 2 layout with synchronized playback controls, allowing users to fully investigate a scene from multiple angles.

- The investigation mode shall open in a new tab.

The investigation mode shall enable operators to synchronize video playback and export investigative playlists covering scenes of interest in forward or reverse at speeds up to 128 times normal playback.

Users shall be able to create playlists from multiple video clips encompassing selected scenes from an investigation.

Operators shall be able to save a current investigation, preserving the associated device list and any created clips for later recall.

- Saved investigations shall be capable of being shared with other operators' similar tabs.

Operators shall be able to export individual video clips or entire playlists to the Core application, storing clips relevant to their investigation independent of the system's network video storage for evidentiary safe-keeping and quick access.

EXPORT

An operator shall be able to create and export a JPG snapshot image of the current frame of video in a cell.

The Client application shall enable video export to any system-accessible media including locally to HDD, CD/DVD, Flash USB device or to network storage.

- Exported video shall be subject to check sum verification.

DISPLAY

- The Client application shall have both built in video decoding and the ability control separate hardware video decoders, providing virtual matrix functionality.
- The Client application shall allow multiple monitor support for up to 6 displays per client workstation, with the use of hardware video decoders.
- The Client application shall allow up to 4 1080p, 30 fps streams per monitor.

EVENTS

- The Client application shall have an operator to respond to events.
- Certain events shall be configurable for acknowledgement.

ACKNOWLEDGEMENT OPTIONS:

- snooze
- in process
- acknowledged
- Authorized operators shall have the ability to derive additional information about an event from the core application.
- Plug-ins – The Client application shall support modular plug-ins for enhanced functionality.
- System and Device Information

Information management

- The Client application shall provide a mechanism to create and assign
- A primary device list shall be apparent in the Client application.

The device list shall be sortable by device name or device ID.

The device list shall be able to be filtered by the following terms:

- simple text-based filter, matching the device name or device ID
- tag-based filtering, showing devices matching the intersection of all assigned tags
- status-based filtering, showing devices with a particular status

User Roles, as assigned by a System Administrator, shall define the limits of a user's ability to access live or recorded video and to export video and other standard client operations.

Authorized users shall be able to share views, including window arrangements and camera selections, with other users, for purposes of collaboration.

When using a mouse to hover over a device in a listing, a popup shall appear with the following information:

- Device state
- Device name
- Device ID
- Thumbnail image
- Associated tags
- IP Address

Hardware Requirements:

- Processor: Intel i-3, i-5 or latest
- Operating System: Microsoft Windows 7 Ultimate SP3 / Windows 8/10 or latest

- RAM: 32 GB DDR RAM ECC
- SSD Storage: 480 GB
- Optical Drive: DVD ± RW
- Video
- Graphics: Intel HD Graphics P47400
- Outputs:
- Display Port (2)
- DVI-D
- VGA
- Resolution Capability:
- Display Port: 3840 x 2160 @ 60 HZ
- DVI-D, VGA: 1920 x 1200 @ 60 HZ

8. Storage Management Application Server

The storage management application server shall incorporate both server functions and storage elements into a purpose-built chassis.

The storage management application server shall not require removal from its rack installation when hard disk drives or power supplies must be replaced.

The storage management application shall record video and audio streams from IP cameras and video encoders on the network.

Video:H.264 in High, Main, or Base Profile streams from both standard resolution and megapixel cameras

The storage management application shall have the following further functions and characteristics:

- Employ the Windows Server 2012 operating system
- Use RAID 6 parity across the storage drives to protect recorded data against a hard disk drive failure
- Use enterprise-level hard disk drives specifically rated for operation in RAID systems
- Employ the following redundancy features
- redundant, hot swappable power supply modules
- redundant, hot swappable system fans

Designed for online service and maintenance and cannot be removed from the rack when hard disk drives or power supplies must be replaced.

Guaranteed recording throughput: 450 Mbps and up to 300 total cameras per storage device under normal and error (RAID rebuild) conditions

Guaranteed downloading throughput: 175 Mbps per storage device under normal and error (RAID rebuild) conditions.

- The storage server shall natively support Optera cameras any combination of cameras from third-party manufacturers supporting ONVIF Profile S.
- Support continuous, scheduled, alarm/event (including analytic), and motion
- Pre- and -post alarm periods shall be configurable
- Support bookmarking of video content
- Support privacy tools that allow administrators to establish maximum retention times

for video

- Ability to report all diagnostic events, including software status diagnostics to a centralized user interface
- Fully manageable from a remote workstation, including the ability to configure settings and update firmware and software Capable of interfacing with a UPS using a USB connector
- The network video recorder shall receive status and control signals from the UPS when it is in backup mode, informing the operator about the amount of charge remaining and triggering a controlled shutdown when the charge becomes zero.

Hardware

- System Specifications
- System Drive: 200 GB SSD
- RAID Level: RAID 6
- Storage: Up to 96 TB
- Drive Interface: SAS/SATA II
- Network Interface (2): Gigabit Ethernet 1000Base-T (RJ-45 connection)
- USB 2.0:2 on rear panel; 2 on front panel
- USB 3.0:2 on rear panel
- Electrical - Power
- Voltage Input: 100 to 240 VAC, 50/60 Hz, auto ranging
- Power Supply: Internal, dual-redundant, hot-swappable
- Environmental
- Temperature
- Operating: 10° to 35°C (50° to 95°F) at unit intake
- Storage: -40° to 65°C (-40° to 149°F)
- Operating Humidity: 20% to 95%, non-condensing
- Mounting: Desktop (feet); Rack, 3 RU per unit

3D Mouse Controller

i. The 3D Mouse must be compatible with all network video management components.

ii. Six-degrees-of-freedom sensor – Intuitively and precisely navigate digital models or camera positions in 3D space.

iii. Advanced ergonomic design – The full-size, soft-coated hand rest positions the hand comfortably, and 15 large, soft-touch, function keys allow quick access to frequently used commands.

iv. Quick View Keys – Fingertip access to 12 views makes it easier to switch cameras.

v. Intelligent Function Keys – Easy access to 4 application commands for an optimized workflow.

vi. On-Screen Display – Provides a visual reminder of function key assignments on your computer screen.

vii. 3D Space Mouse Modifiers – Fingertip access to Ctrl, Shift, Alt and Esc keys saves time by reducing the need to move your hand between mouse and 3D Mouse.

viii. Virtual Num Pad – Allows direct numerical input into your application using your standard mouse rather than the 3D Mouse.

ix. The 3D Mouse must be part of an integrated system and shall be configured so any number can be added to the system. When combined with user interfaces (UIs), network storage managers (NSM's), encoders, IP cameras, and video consoles, the 3D Mouse forms an integral part of a complete network-based video control system.

x. Hardware

- Power Supply
- Input Connector Type: Universal, interchangeable
- Connectivity
- 3D Space Mouse Interface: USB2.0
- Cable: USB
- Module Specifications
- 3D Space Mouse Keypad
- Joystick: Fully proportional PTZ, variable speed; with zoom, iris, and focus controls
- Environmental
- Operating Temperature: 0° to 40°C (32° to 104°F) air intake of unit
- Storage Temperature: –40° to 65°C (–40° to 149°F)

9. Enterprise and Scalable Management Platform

The VMS shall be an enterprise solution and scalable to support unlimited number of cameras. VMS should support latest Windows Server operating system on Server machine. It should support latest Windows OS on Client machine, independent of what operating system is there in the servers. VMS should support SQL/ MySQL/ Oracle DBMS.

a. Distributed Architecture and Openness

The VMS shall support distributed video architecture which seamlessly integrates the video operations of numerous systems onto one virtual platform, allowing security operators to view and control all cameras, whether across a single facility or across the multiple locations. The VMS shall support ONVIF profile and integrate all cameras supporting ONVIF profile.

b. Standards for Software

The VMS shall be designed and developed to the following standards:

- ISO 9001-2008
- ISO/IEC 15504 Level 3 or higher (SPICE 2.0 Software Process Improvement and Capability Determination)
- SEI CMM Level 5 (American Software Engineering Institute - Capability Maturity Model)

c. Server-Client Architecture

The VMS shall have Enterprise Database servers, Recording Servers, Analytics Server, Storage and Operator workstations.

The VMS shall support minimum 2500 cameras managed per Enterprise Database Server. Systems shall be scalable by adding additional Servers.

The VMS shall have Analytics Servers dedicated to analyse video streams. The Analytics Servers shall process the live video using preconfigured rules and Intelligent Video Analytics algorithms to determine events of interest.

d. Fault Tolerant Architecture and Redundancy

The database server shall provide a central fault tolerant repository for all configurations and run time information for the complete system.

The VMS must be capable of running a pair of similarly configured Database Servers in a hot backup configuration where at any point in time, one is the acting Primary and the other is acting as the Hot Backup. The backup Database Server shall be continuously synchronized with the master Database Server to ensure that it is always up-to-date and ready for a fail-over, when required. The failover for Database Server should be seamless and should not affect recording of cameras.

It must be possible to remove one of the redundant systems for maintenance without interrupting operation, and upon its reinstatement, automatically re-synchronize the databases, again without interruption to system operation.

The VMS shall support Primary and Backup Recording Servers allowing N: 1 to N: N redundancy as per BOQ. The failover and fail back mechanism between Preferred and Backup Camera Servers shall be configurable and support both automatic and manual operation. The failover process for Recording Server should not take more than 10 sec.

e. Concurrent Web Clients and Console Stations

The VMS shall provide Internet Explorer Clients for users other than Operators in Command & Control Room. These clients will be used for viewing of cameras by Security Officers and other authorized users other than in Command & Control Room. Incident and alarm responses are not required for these clients.

The VMS shall provide a professional level Surveillance Console interface for control room operators. Its primary role shall be to meet the operational requirements related to surveillance.

f. Operational Features of VMS

The VMS console shall have a Navigation Pane that include separate tabs to display available cameras, Views, groups and locations available to the operator based on their security settings. It shall include a multi-level camera tree up to at least 5 layers deep with built-in filter search capability. It shall support user defined logical groups.

The VMS shall have flexible workspace with simultaneous display of Live and Recorded video from the same or different cameras. Information describing the camera and associated video shall be shown in the tile including camera name, camera number, camera health status and whether the camera is currently recording, replaying video, paused or playing live video.

The VMS shall have Wild-Card search feature for cameras in Camera Tree and Groups.

The VMS console shall have a timeline control to display and play back recorded video for one or more cameras. Playback shall be possible on 1 or more cameras simultaneously for all cameras currently displayed in the Video Workspace.

The Timeline toolbar shall include Play, Pause, Snapshot, Fast Rewind (up to 1024x), Frame Rewind, Fast Forward (up to 1024x), Frame Forward, Jump Back, Motion Search and Calendar Control as standard features.

The timeline will also have zooming and scrubbing feature for easy analysis of recorded videos.

The VMS console shall have Motion Search feature that allows searching for areas of motion in recorded video. The Motion Search feature shall provide the ability to define a region of interest for each camera currently included in the timeline. The region of interest will be displayed on the camera image in the Video Workspace and each shall be separately configurable.

The VMS console shall provide a visual location for cameras that have recently been viewed by the operator. Cameras displayed in this location shall be represented by a live view image from the camera at reduced frame rate for easy reference.

It shall be possible to minimize each individual element of the Surveillance Console to maximize the use of the screen for video display.

The VMS shall support Snapshot feature, whereby on the click of a button operator shall captures the current frame of video and saves it as a bitmap image. This shall be available when viewing both live video and recorded video.

The VMS shall support Sequencing in Views, whereby the pre-sets of PTZ cameras as well as fixed cameras are cycled on a timed basis, within a single view or within the view port of a multiple camera view.

The VMS shall support Image Blocking preventing unauthorized operators from viewing live or recorded video when a specific class of operator takes control of a camera, thus helping to prevent potential collaboration between operators and suspects.

g. Mobile Client for Video

The VMS shall have integrated Mobile clients to view the cameras from the Smart mobile phones. The mobile application shall support iOS/ Android mobile OS.

Video shall be streamed at reduced frame rates and increased compression in case of insufficient network bandwidth. When sufficient network bandwidth becomes available video quality is automatically restored.

Mobile client shall have a navigation pane to select the cameras, locations and groups of cameras.

Mobile client shall support min concurrent camera views in Smartphone device and concurrent camera views in tablet devices.

PTZ function shall be available in mobile app for the PTZ cameras. Selection of pre-sets in PTZ camera shall also be available in mobile client

Mobile client shall display real time frame delivery statistics for a video stream as an overlay on the video.

h. Bi-Directional Audio Support

The VMS shall support Bi-directional Audio providing a simple and inexpensive IP Intercom solution utilizing the existing network camera.

i. Edge Recording and Backfill

The VMS shall support edge recording of video on SD card inside the camera in case of network connectivity between camera and VMS is down. The VMS shall support restoration of edge recorded video in the VMS storage once the network connectivity between camera and VMS is up.

j. Digitally Signed Export of Camera Videos

The VMS shall support export of video for evidentiary purposes. It shall be possible to select the portion of video required and export only that portion in Windows Media Format and Native Format.

The VMS must support all exported recordings and exported audit logs to be digitally signed to prove authentication (origin of the recording and audit log) and integrity (exported recording and audit log have not been altered or tampered with).

The VMS system shall provide a default digital certificate for signing the exported recordings and audit logs. Customization shall also be provided to allow for the user to supply his/her own digital certificate.

k. Camera Temper Detection Feature

The VMS shall support temper detection for the connected cameras. Temper detection shall include changed field view, camera blurred and camera blinded.

l. PTZ Camera Control

The VMS shall support Area configuration to allow users to view specified cameras only.

The VMS shall support Control Level determining if a user is allowed to operate the PTZ

controls for a camera.

The VMS shall support Control Reservation Period allowing if a particular user has controlled the camera no other user can control the camera until this reservation period has expired. Users with a higher security level shall be able to take control of the camera at any time.

m. Recording and Archiving of Camera Videos

The system has to provide sufficient storage to record all cameras for 30 days at 1080p, 25 fps, H.264 compression.

The VMS shall provide the ability to automatically archive all recordings. It shall be possible to automatically archive any type of recording at a preconfigured period after the recording has completed. It shall be possible to modify the automatic archive setting for each recording individually, as required.

The VMS shall support continuous background recording, scheduled recording, event activated recording and user activated recording for all connected cameras.

n. Search and Playback of recorded Videos

The VMS shall provide a simple search for all video recorded. The user selects the time indicator which shows a calendar and time line. The user selects the required search period. Once the time criterion is entered, the "search" is selected. Video recorded during the selected period will be returned by the search.

The VMS shall provide an advanced search of recorded video. The search shall be based on recording time, camera and recording details. Wildcards shall be accepted for the Point ID, description, area, priority and value for alarm/event activated recordings.

o. Intelligent Video Analytics

The VMS shall have an integrated Intelligent Video Analytics system from same or other OEM.

Events from the Intelligent Video Analytics system shall be passed back to the VMS to start a recording and generate an alarm of configurable priority.

The Video Analytics System shall have following algorithms-

- person entered/exited restricted area
- person loitering in restricted area
- people converged or crowd gathering
- person trespassing - tripwire
- vehicle entered/exited restricted area
- vehicle parked in restricted area
- Video signal lost
- Camera defocused/ blurred
- Camera blinded
- Camera scene changed
- object left unattended
- object removed/ possible theft

p. Digital Zoom and Image Enhancement on live video

The VMS shall support the ability to digitally zoom into an area of the image as well as provide the ability to enhance the image viewed by adjusting the levels of brightness, contrast, noise levels and sharpness for both live and recorded video.

q. Alarm Module

The VMS shall have integrated Alarm Module for video system and analytics alarms.

The Alarm module shall have Alarm and Event summary with Video Clip attached.

The Alarm module shall provide Audio Alert in different audio tones for Low, High and Urgent priority alarms

The Alarm module shall provide Alert in different colours for Low, High and Urgent priority alarms

The VMS shall have the feature to pop-up video from the camera on a dedicated alarm monitor in case of an alarm is generated in that camera. The cameras will be queued in sequence in case of multiple alarms till they are acknowledged by the operator.

The system shall have feature to send SMS alerts to predefined users in case of predefined priority alerts.

r. Diagnostic Module

The VMS shall provide diagnostic modules to assist with system health assessments and collection of diagnostic information.

The Diagnostics applications shall provide a unified user interface for running tests, recording system activity, collecting diagnostic information and viewing system log files.

It shall be possible to collect diagnostic information on all components of the VMS application including Database Servers, Recording Servers, Clients and network activities.

s. Enterprise Command Wall at Central Command Station:

The Video management System shall include an Enterprise Command Wall with touch interface at the Central Command Station. The Command Wall shall be a high definition multi touch screen with a minimum size of 60 inches.

The Enterprise Command Wall shall be used as a central resource for the review and discussion of operating activities and incident management.

The Enterprise Command Wall shall provide seamless integration with CCTV, Access Control, Fire

Alarm System and Perimeter Intrusion Detection System.

The Enterprise Command Wall shall have following features:

- Map navigation using multi-touch gestures - Pinch to zoom, Drag to pan
- Single touch navigation to area of interest
- Progressive Disclosure of map elements such as cameras, Access points and Sensor points.
- Contextual Incident notifications
- View incidents on map elements
- Contextual alarm notifications
- Alarms on map elements
- Enhanced Ontology to support Security and Fire
- Live video embedded in map, Camera Control (PTZ) using touch gestures, Video playback /Play/Pause /Fast forward/Rewind/Instant 30s rewind Controls

The Enterprise Command Wall shall be capable of all sub-systems at a single user interface to improve situational awareness and responsiveness particularly in abnormal situations.

t. Incident Management System:

The VMS shall have an integrated Alarms, Incident Management and Reporting module. The

Incident Management System must have following features as minimum-

- Automatic creation of an incident based on a system detected condition
- Manual creation of incident
- Scheduled Incidents
- Customized Incident summary View
- Incident ownership and handover
- Execution of corresponding Standard Operating Procedures (SOPs)
- Authorized/Automated steps
- Import/Export of Standard Operating Procedures (SOPs)
- SOP Design User Interface
- Chronological comments
- Escalation- Manual/Time based
- Auto acknowledge of associated alarm
- Live video and Map orchestration
- Incident compliance Report
- Incident Summary Report

u. SPECIFICATION

1/2" colour camera of CMOS solid-state type

Resolution : at least 752 pixels (h) x 582 pixels (v)

Sensitivity : 0.5 lux for distinguishable picture, minimum

Geometric distortion : none (Lag and image distortion shall be minimized Automatic white balance)

Signal to noise : 5 (6 dB minimum)

Light range : 1 min with auto-iris lenses, Auto black in reference to the

darkest picture element Ten-digit insert text for camera recognition (minimum) 625 lines and 50 fields per second

v. SYNCHRONISATION:

- Line - Lock: Synchronises the camera to the power line zero crossing, for a roll-free vertical interval switching
- Genlock: Accepts composite video, composite sync, or H & V drivers for genlock operation
- Crystal – Lock: Internal crystal reference with full genlock capabilities to allow master synchronisation Lenses shall be with "C"-mounts.

VIDEO OUTPUT SIGNALS:

Standard video signal: - 1 Vpp at 75 Ohm asymmetrical

Two wires output: - 2 Vpp at 150 Ohm symmetrical

CAMERA LENSES

Lenses shall be with "C"-mounts.

Lenses for cameras mounted outside the tunnel: f/1.61 minimum range 11 - 100 mm or as approved

Lens for cameras inside the tunnel: f/1.4, 16 mm or as approved

The zoom shall be motor driven and remote-controlled. The lens shall have auto iris.

All other technical specifications as those of the camera are also valid for the lenses.

CAMERA HOUSING

The waterproof camera housing shall consist of highly corrosion resistant stainless-steel material No.l.4404.

System of protection:- IP 67, IK 10

Input voltage:- 240 V, 50 Hz

Window heater: - 20 W, thermostat controlled, overheat limiting thermostat A sun shield for all cameras outside the tunnel shall be provided.

CAMERA MOUNTING BRACKET

The camera mounting brackets shall be used for mounting the cameras on the tunnel wall or on a column in the free field area. Also, the dome cameras shall be installed with this camera mounting bracket.

The material of the mounting bracket shall be of stainless steel with painting and shall be resistant against all environmental conditions. All fixing bolts shall be made of stainless-steel No. 1.4404. Connection cables between each camera head assembly and the corresponding camera distribution box shall be fed down the pole internally.

10. Dome Camera

The dome cameras in the free field area shall monitor the portal areas of the Tunnel. The dome cameras shall be equipped with additional pan, tilt and zoom function (PTZ).

The electrical connection to the mounting shall be of waterproof fixed plug type.

The mechanism of the pan, tilt and zoom function shall not allow more than 1/3° free movement

(play) in any direction locked, a pan movement of 0° to 360° in horizontal plane and a tilt movement of +I- 90° minimum. Velocities of movement shall be approximately 6°/sec. for pan and approximately 3°/sec. for tilt.

The housing of the pan/tilt-system shall be waterproof; system of protection: IP 67, IK 10.

The exact location of the cameras, in the free field area shall be defined by the Contractor in accordance with the Client on-site, depending on the landscape and the final prevailing conditions. It shall be guaranteed that, with the placement of the camera, the whole portal is visible.

The dome cameras shall be installed on therefore foreseen camera columns.

11. Optical Video and Data Transmission

The video signal of each camera shall be transmitted via an own fibre of a 9/125 m single mode optical-fibre cable at the range of 1320 or 1550 nm from the camera to the Control Room.

The second fibre of this cable shall be used for data transmission (camera error, etc.). The third fibre shall be used for the control of the pan/tilt/zoom unit. The fourth fibre shall be spare.

Appropriate transmitters and receivers changing electrical video signals into optical signals and vice versa shall be provided.

Noise clearance: - at least 50 dB

Video signal: - FBAS 1 Vss at 75 Ohms (Functional behaviour assessment surveillance)

12. Optical Video Transmission Fixed Cameras

The video signal of each camera shall be transmitted via an own fibre of a 9/125 μm single

mode.

fibre-optic cable at the range of 1320 or 1550 nm from the camera to the multiplexer. A second fibre of this cable shall be used for data transmission (camera error/ etc.) Appropriate transmitters and receivers changing electrical video signals into optical signals and vice versa shall be provided.

Noise clearance: - at least 50 dB

Video signal: - FBAS 1 Vss at 75 Ohms

13. Camera Distribution Box

Each camera shall be connected with an own camera distribution box containing the necessary hardware to interface the power supply, control signals and the video signal as well as the electro-optical converter needed for transmission.

For dome cameras in the free field area, the distribution box also shall drive the pan/tilt facility and the motor zoom as ordered from the remote control.

Suitable terminations shall be provided for incoming and outgoing cables. The camera distribution boxes shall have a degree of protection of IP 67and all doors of the camera distribution boxes shall be protected by a suitable lock. Preferably all boxes shall be of identical size. If this is not possible due to physical constraint in the tunnel, not more than two standard box sizes shall be used, one for using inside the tunnel and one for the outside cameras. Construction details of the boxes and type of the lock shall be subject to the approval of the engineer. Details shall form part of this submission.

Protection devices of an approved design shall be connected to each signal line at each camera distribution box in such a way, that no damage occurs under fault conditions. The Contractor shall state the surge protection capabilities of these limiting devices. These devices shall protect the equipment from main voltage (250 V) across a pair of signal lines or between a wire and ground and surges induced on the lines due to lightning etc.

Each outside camera distribution box shall be placed at a suitable point in that way, that the movements of the associated camera are clearly visible and can be easily checked. So, the best mounting point would be the camera column / pole itself.

Camera distribution boxes for tunnel cameras shall be mounted near to the camera above the clear open space on the tunnel wall. The Contractor shall state the maximum distance that is allowed between the camera and the camera distribution box.

Were column I pole-mounted camera distribution boxes are used, all cables to the cabinet shall be laid inside of the column I pole and further in conduits (in ground). The cables shall be easily maintain-able from ground.

14. Video Recording Unit

The Video Recording Unit shall be dimensioned for all cameras. The Video picture Recording Unit

consists of:

- Recording unit
- Storage
- Interface to Video-LAN

The analogue digital signal from the camera shall be transmitted to the camera distribution box / which shall convert the electrical signal into optical signal. Through optical fibre cable the video signal shall be transmitted to the multiplexer, which shall be situated in the Niches. From the Multiplexers, the video signals shall be sent via an optical fibre cable ring to the Control Room Building. In the Control Room Building the signals shall be de-multiplexed and digitized by the Digital Video Codecs. After the video signals were digitized, they shall be stored on hard disks (RAID Units).

15. Video Detection Unit

The execution of the Video Detection Units shall be made with built in frames in the distribution cabinets.

The system must be able to detect pedestrians, and vehicles which are entering the tunnel.

The Video Detection Unit shall be able to evaluate the video images also in case of a reduced

illuminance and reduced contrast because of dust in the tunnel, etc.

a. DETECTING AT PORTALS

For detecting in the free field areas; one detection camera at each portal side shall be installed. With the Video Detection Unit it shall be possible to differentiate between pedestrians and vehicles. If a vehicle passes the tunnel, no alarm shall be triggered. If a human or a vehicle will enter the tunnel, an alarm shall be activated in the Control Centre and equipment Room . The CCTV images next to the alarm place shall be displayed on the CCTV alarm screens.

The detection of humans- never mind of standing or moving -shall be realized within 20 seconds.

b. DETECTING INSIDE TUNNEL:

For detecting purposes inside the tunnel tube, one camera each 150 m shall be installed (TV. D8, TV. D16, etc.). Those cameras shall have additionally to the common monitoring function, the functionality of detecting. If a vehicle passes the tunnel, no alarm shall be triggered.

The selected cameras inside the tunnel tube shall detect the velocity of the vehicles. The velocity measuring of the velocity shall be detected in a span between 5 and 100 km/h. Further if the velocity of the vehicle falls below an adjustable threshold value, information of the vehicle velocity must be handed over to SCADA and further to the Tunnel Ventilation System.

c. SOFTWARE & FUNCTIONS: -

- Suitable software for the control of the whole CCTV System, including picture switchboard and recording unit.
- Software to show every selected picture (Live pictures or pictures from the storage).
- Administration and configuration of the video network (Video-LAN)
- Tools for burning a CD and print the video pictures

d. INFRARED LED ILLUMINATORS SEMI-COVERT

Electrical

Input Voltage	12 VDC ±10%; 24 VAC ±10%
Power Consumption	12 W maximum
Power Cord	2.5 m 12 or 24 VAC/DC

General

Wavelength	850 nm/940 nm
Average Life (Lamp)	10 years
Construction	Aluminum body, stainless steel bracket,

	polycarbonate cover
Finish	Gray polyester powder coat
Operating Temperature	–40° to 50°C (–40° to 122°F)
Storage Temperature	–50° to 75°C (–58° to 167°F)
Weight	Unit Shipping 0.65 kg (1.40 lb) 0.80 kg (1.70 lb)

Mechanical

Bracket Mounting	6.50 mm (0.25 in) hole diameter
Bracket Adjustment	2, 4 mm AF hex (M6 hex button head)

e. CERTIFICATIONS / PATENTS

- CE
- FCC, Class B
- UL/CUL Listed
- Meets IP66 / IP67 rating (environmental) and IK9 / IK10 (vandal resistant)

f. SUPPLIED ACCESSORIES

Units are factory-installed with a 35 x 10° Interchangeable Diffuser System (IDS); an additional 60 x 25° IDS is supplied.

g. RECOMMENDED ACCESSORIES

RC - LED	Remote control for IR850, IR940, or WLED illuminators
LENSPKS - LED	Wide angle lens pack (80° and 120°) for IR850S-65, IR940S-30, or WLEDS-50
LBKT- LED	Mounting bracket for installing IR850, IR940, or WLED illuminators on walls or flat surfaces

h. INTEGRATED COMMAND AND CONTROL

Standard	Built-in photocell for automatic on operation; LED Status Feedback System provides status on performance of the unit; photocell following output
Advanced	Accessed with remote control: – Power adjust from 20 to 100% – Photocell sensitivity adjust – Timer function (up to 30 minutes) – Telemetry control or remote dimming – LED Status Feedback System on/off – Restore factory default settings

16. Camera Column

The column shall be made of galvanized steel. Height above ground: 5 m

The exact location of the cameras, out of the tunnel, in the free field area shall be defined by the Contractor in full accordance with the Client on-site, depending on the landscape and the final prevailing conditions. It shall be guaranteed, that with the placement of the camera, the whole portal is visible. The cabling shall run in the camera column. Furthermore, the columns

shall have a lockable opening into the interior part of the column for cable installations. The opening shall be in a height, which is good reachable for the installation and maintenance people.

The column shall be fixed in foundations (the costs therefore shall be calculated into the price of the column). The column shall be connected to the earthing system by the Contractor of Telecommunication.

Table 10: TECHNICAL DATASHEET FOR CCTV SURVEILLANCE SYSTEM (BULLET CAMERA)

Sr. No.	Parameters	Technical Specifications
3 MEGA PIXEL FIXED BOX CAMERA INSIDE THE TUNNEL		
1	Image Sensor	1/2.8" Progressive CMOS
2	Resolution	2048 x 1536
3	Minimum Illumination	Colour- 0.5 Lux @ 30IRE, Black & White- 0.05 Lux @ IRE
4	Lens	2.7mm to 12m Motorized Focus/Zoom Lens, F1.4
5	Back Light Compensation	BLC/ HLC
6	Motion Detection	On/ Off
7	Wide Dynamic Range	True WDR; 120 dB
8	Day/ Night	Auto/ Color/ BW, True Day/Night with ICR
9	Shutter Speed	1/10 to 1/10000 Sec
10	Noise Reduction	3D Noise Reduction (3DNR)
11	Signal to Noise Ratio	>=50dB, Back Light compensation ON/OFF selectable
12	IR Illumination	Built-in IR LEDs with up to 100m illumination
13	Privacy Mask	Mask up to 4 areas of a scene from view and record
14	Video Compression	H.264, MJPEG
15	Video Streams	Primary Stream: 1080p/ 720p/ D1 @ 25/30 fps Second Stream: D1/CIF @ 25/30 fps Third Stream: 720p/D1/CIF @ 25/30 fps
16	Network Protocols	IPv4/IPv6, HTTP, HTTPS, TCP/IP, UDP, UPnP, ICMP, IGMP, RTSP, RTP, SMTP, NTP, DHCP, DNS, PPPOE, DDNS, FTP, QOS, SNMP v2c/v3, LDAP (Client), NFS, RTCP, Bonjour
17	Security	User account and password protection
18	Supported open Protocol	ONVIF Profile S & G
19	Onboard Storage	Up to 128 GB Micro SD Card
20	Onboard Recording Type	Event trigger recording Continuous and scheduled recording Automatic recording when network fails
21	Event	Motion Detection, Video Tamper, Network Disconnection
22	Event Notification	Record in SD Card/ FTP, Relay Output, Snapshot
23	Alarm Input/ Output	2 Inputs, 1 Output
24	Power Source	12VDC ±10%, 24VAC ±10% 50Hz, PoE 1EEE 802.3af
25	Operating Temperature	-30°C to 60°C
26	Operating Humidity	20 to 80% RH (non-condensing)
27	Vandal Resistant	IK10
28	Ingress Protection	IP67

29	Regulatory	• CE – EN 55022 (Class A), EN 50130-4, EN 60950-1 • UL and cUL Listed – UL 60950-1, CAN/CSA – C22.2 No. 60950-1-07 FCC (Class-A) – 47 CFR Part 15

Table 11: TECHNICAL DATASHEET FOR OUTDOOR PTZ CAMERA AT TUNNEL PORTALS

Sr. No	Specification	Parameter
30X, 2Mpx High speed PTZ Dome Camera		
1	Image sensor	1/2.8-inch CMOS Sensor
2	Resolution	1920 X 1080 @ 60FPS
3	Dynamic Range	130db
4	White balance Range	2,500° to 8,000°K
5	Signal to Noise Ratio	50dB
6	Electronic Shutter Range	1 ~ 1/10,000 sec
7	Minimum Illumination	Color (200 ms) 0.08 lux ; Mono (200 ms) 0.015 lux
8	Imaging Technology	– Anti-Bloom Technology – 3D Noise Filtering – Enhanced Tone Mapping
9	Lens	4.3 mm (wide) ~ 129.0 mm (tele)
10	Optical Zoom	30X
11	Digital Zoom	12X
12	Horizontal Angle of View	55.4° (wide) ~ 2.9° (tele)
13	Iris Control	Auto iris
14	Active Noise Filtering	Yes
15	Presets	Min 256 preset
16	Tours	16
17	Preset Accuracy	Pan ±0.1°; Tilt ±0.05°
18	Auto flip feature	Yes
19	FPS	Camera should support 1920 X 1080 @ 60 fps
20	Video Streams	Both Primary and Secondary Stream at 1920 X 1080 @30FPS
21	Audio	Embedded with stream 1 and stream 2 G.711 A-law/G.711 U-law
22	Supported Protocols	TCP/IP, UDP/IP (Unicast, Multicast IGMP), UPnP, DNS, DHCP, RTP, RTSP, NTP, IPv4, IPv6, SNMP v2c/v3, QOS, HTTP, HTTPS, LDAP (client), SSH, SSL, SMTP, FTP, and 802.1x (EAP), GB28181
23	Built in Analytics	Object Counting , Abandoned object , Stopped Vehicle , Loitering Detection, Intrusion Detection , Wrong Direction , Camera sabotage .
24	Local Storage	Up to 32GB onboard Micro SD, SDHC Compatible
25	Analytics	Motion Detection and Camera Sabotage
26	Pan Movement	360° continuous pan rotation
27	Tilt Movement	+1° to –90°
28	Preset Speed	Pan 430°/sec; Tilt 200°/sec
29	Variable Manual Speed	Pan 0.1°/sec to 100°/sec Tilt 0.1°/sec to 50°/sec
30	Ports	RJ-45 connector for 100Base-TX; Auto MDI/MDI-X; Auto-negotiate/manual setting
31	Alarms	1 X inputs and 1 X output
32	Input Power	HPOE and 24 VAC and 24VDC; 50 VA
33	Operating Temperature	-40 to 50deg C
34	Operating Humidity	10% to 100% (noncondensing)
35	Housing	Aluminum Housing with Polycarbonate Bubble
36	Environmental Protection	Ingress for Water & Dust - IP66 / IP67 or higher

37	Vandal Proof Certification	IK10 or higher
38	Certificates	CE & FCC & UL CUL
39	ONVIF Compliant	ONVIF Profile S and Profile G conformant

5.2.15 Tunnel Radio

This covers the whole Tunnel Radio equipment of all the required equipment, material, accessories, and all labour.

The Contractor shall provide a Tunnel Radio System, which guarantees a complete radio capability in the whole tunnel (even in the Accesses if any). Transmitter and receiver frequencies are required for road and emergency staff.

The realization of those shall be calculated into the prices of the Tunnel Radio System.

If any coordination is necessary, all coordination (even with the local fire brigade, rescue service, police, military, etc.) shall be included in the prices of the Tunnel Radio System.

Connection to control centre shall be (made by Contractor of E & M).

The Signals of the Tunnel Radio System shall be transmitted from the LF-connecting network to the telecontrol system with TCP / IP cabling.

The whole Tunnel Radio System shall be as uniform as possible. Further on devices, which are easily to expand, and change shall be used.

The different parts of the Tunnels Radio System shall be arranged by easy changeable, pluggable units with very accessible operator's controls. Also, those parts of the radio system, which shall be maintained, shall be very accessible.

The required values of the tunnel radio system shall be kept, even by these environmental conditions:

- Relative air humidity 100 % till -20°C
- Ambient temperature by parts of the plant in heated rooms of 0°C - + 40°C
- Ambient temperature by parts of the plant, which are located elsewhere from -20°C - +50°C.
- Power supply voltage with a range of -15% - +10%.
- System frequency of 50 Hz ± 2 %

1. Scope of Work

- Radio Service and Channels
- Amplifier
- Tunnel Antenna – Leaky Feeder Cable
- Antenna Column
- Free Field Antennas
- Cabling
- Desktop Station

2. Technical Specifications

<u>Functionality of Tunnel Radio System</u>

a. The operation stations of the Tunnel Radio System shall be provided in the control centre and in the equipment room buildings. The Tunnel Radio System also shall be integrated in the telecontrol system (SCADA).

b. The Tunnel Radio System shall provide an uninterruptable radio connection to the headquarters and operation centres for all vehicles and handheld device of the tunnel operator's staff, emergency staff and vehicles, which passes the tunnel.

c. The communication of all channels in the tunnel shall be independently, simultaneous and failure free.

d. No disturbing interferences shall occur at the tunnel portals; there are crossovers from the free field radio area to the tunnel radio area.

e. The radio signals of the free field area shall be handed over with the free field antennas and shall be transferred to the radio central unit at the equipment Room control room.

f. The Contractor shall measure the best location for the antenna column. The measurement protocol shall be handed over to the client. In accordance with the client, and the measurement, the exact location of the radio column shall be determined.

g. In case of breakage, malfunction information shall be indicated for every channel. This malfunction information shall be available in the tunnel radio cabinets as potential free two-way contacts. Also malfunction information of the tunnel antenna monitoring, and the malfunctions of their power supply units shall be indicated at SCADA.

h. The Tunnel antenna system shall be wide band system; for the frequencies between 68 MHz and 470 MHz. The channels may have any frequencies, which are in this frequency band.

i. An enlarging of additional channels in the Tunnel Radio System shall be easily, and without any adjusting operations to do. Also, a changing of frequencies, at already existing channels in the system, may be done as easily as the enlargement. The changing shall be done without intervention of installed transmitting system in the tunnel. Only in the Equipment Room / control room the equipment shall be adjustable. The changing of frequencies shall be able with common maintenance tools and measuring devices.

j. The transmitting of the individual channels must not be influenced by each other.

k. The antennas in the free field area shall be situated on the column. It shall be a tubular column and situated in location, depending on the best receiving frequencies. These antennas shall be directional antennas, which shall be directed to the respective bases and relay stations.

l. To avoid a coupling between the free field antennas and the tunnel antenna, a decoupling, which is as high as possible (about 140db), shall be realized. if the decoupling of the individual channels is not enough, additional methods shall take place, to guarantee a fully functional Radio System. By the overtaking of the radio system by the client, the definitely decoupling of the radio system shall be verified metrological.

m. The Tunnel Radio System shall work automatically and without external support.

n. The Contractor shall calculate the values of the system.

o. In the tunnel the transmitting probability of the radio signals shall be 98%.

p. The radio devices of the system shall have transmitted power between 1 W and 10 W. The mobile radio devices shall have the small transmitting power, as well, as a mini flexible antenna with a negative antenna gain.

q. All parts of the radio system shall be supplied redundantly. The power supply units shall be supplied by two separated voltages (Normal supply and UPS), and separately protected be miniature circuit breakers. A malfunction of a power supply shall be indicated.

r. Not even parts of radio system shall be supplied via HF – cables.

s. All housing of devices and distributors shall be connected to the earthing system (by the Contractor of tele communication).

3. Radio Service and Channels

The number of channels is determined, and their frequencies shall be determined in accordance with the Indian standards, client and the local requirements.

The equipment of the tunnel Radio System in the tunnel tube shall be placed in the (control) cabinets of the EM niches. The Contractor shall avoid a collision with other equipment, placed in the EM niches.

a. IMPEDANCE OF TUNNEL RADIO SYSTEM

All components of the radio system in the free field area shall be executed 50 Ohm technology.

b. SURVEILLANCE OF CABLING

An appropriate surveillance system shall be erected (e.g. (audible) pilot signal). The signals shall be transferred as potential free contacts to tunnels control system.

The surveillance system shall contain at least following components:

- HF components for transmitting and receiving equipment, pilot signals, monitoring of cabling, inclusive all evaluation units
- Filter, equalizer, pre-amplifier, overvoltage protectors, test sockets, etc.
- Cable joints, system switches, inclusive cabling and terminals to the HF-connecting networks, and transferring of the message.

Desktop stations shall be erected in the Control Centre and in the equipment Room. They are for enabling the tunnel operators speaking into the Tunnel Radio System. Also, the possibility to play messages shall be given at the desktop stations.

The beginning and ending of a message shall be indicated.

c. MEASUREMENT OF TUNNEL RADIO SYSTEM

- Design – Measurement:

Before the beginning of installing the tunnel radio system, the receiving relations at the tunnel portal / control room

- Takeover – measurement:

After finishing of installation work of the Tunnel Radio System, measurements shall be taken to guarantee the functionality on one hand, and the compliance of all standards on the other hand.

The Contractor shall hand over a paper original as well as an electronic copy of the measurements.

4. Details of Tunnel Radio System

a. MALFUNCTION INFORMATION

The malfunction information shall be potential free contacts and shall be available directly at the distributors. This malfunction information is necessary:

- General malfunction radio
- Malfunction optical transducer
- Malfunction for each channel
- Malfunction for each part of the leaky feeder cable
- Malfunction of every wide band amplifier (ON / OFF)
- Malfunction of connection to control center
- Malfunction of complete tunnel radio system

If more malfunction information is required for full operation, they shall be calculated in the price of the Tunnel Radio System.

A monitoring of HF free field transmitters shall be provided. If one transmitter occupies a frequency for a long time, the connection will be disconnected automatically after 10 min.

b. TECHNICAL REQUIREMENTS

The devices of radio system shall not cause a sound pressure level in the working rooms, which is more than 50db(A).

All equipment of the Tunnel Radio System shall guarantee a simultaneous and disturbing free operation. It shall be verified, if the foreseen frequencies are free of intermodulation among themselves. If they are not free of it, corresponding actions shall take place.

In case of power loss, the device of the radio system shall not be damaged. If the power supply returns, the radio plant shall start and work automatically and self- acting again.

c. OTHER REQUIREMENTS

i. Measuring Sockets:

Measuring sockets with defined coupling shall be installed at the terminals of the tunnel antennas. Although a damping of the out-coupling is required, so that all in and output signals can be monitored by common measurement devices.

ii. Measurement Technique:

The Contractor shall deliver interface adapters and interface cables as well as according maintenance software inclusive manuals.

iii. Coaxial Interconnection:

- The HF-Coaxial interconnections shall correspond internally to the IEC-Standard types BNC, N and SMA.
- Externally they shall correspond to IEC- Standard types BNC, N.3.5/9.5 and 4.1/9.5 and 7/16 and 3.5/12.
- If the Contractor uses other types, corresponding measuring tools shall be delivered.
- Additionally, the HF-interconnections of the leaky feeder and coaxial transport cables shall be extensively silvered inside (at the contact areas) and have a protection against oxidation outside.
- All coaxial interconnections which are stressed by weather or washing solutions, shall be protected against these influences by shrinkable tubes or else.
- if there are shared connections, multi- terminals shall be used. if litz- wires shall be connected, wire end ferrules shall be used.

d. CONTROLLING

The UPS- supplied parts of the tunnels radio equipment shall work with zero-signal current principal. Other controlling equipment shall only work with this principle, if no substantiated reasons are against it. Controlling equipment, which may cause a transition-signal, shall work with the principle of operating current.

potential free contacts are necessary for controlling. They shall be dimensioned for a capability of at least 0.2 A and 50 VDC.

The tunnel antenna shall not be used for transmitting of controlling signals.

e. LOW FREQUENCY SIGNALS

Standard level: 6 dBm at 600 ohms (±0.5dB)

(A) Output signals of radio receivers:

The standard level shall be reached at every interface with a modular frequency of 1 kHz and this hub:

- 1.62 kHz with phase modulation (PM)
- 3.0 kHz with frequency modulation (FM)

(B) INPUT SIGNALS at every interface:

With a frequency of 1 kHz and the defined standard level of the frequency hub at each transmitter:

- 1.62 kHz with phase modulation (PM)
- 3.0 kHz with frequency modulation (FM)

(C) The type of modulation shall be the same at all devices of the radio service. The input signals at every interface are:

- Frequency response for outgoing signals: The tolerance scheme according to CCITT / 5 shall be used.
- Noise Voltage: if there are no. LF - signals on the cable, the noise voltage shall be less than 46 dBm.
- Equalization of wiring: The plant shall be able to equalize wirings up to a 10km, so that a tolerance according to CCITT / 5 at the frequency response may be kept.
- Feedback at 4 wire wiring: An incoming signal with a level of 6 dBm and a frequency of 1 kHz shall not cause a signal in the outgoing wiring with a level higher than 46 dBm.

f. PRECAUTIONS FOR FUNCTIONAL TEST

For measurements of frequency and levelling at the high and low frequency parts of the radio devices, the Contractor shall provide measuring and control sockets. It shall be possible, to take the measurements during operation.

At the control outputs, the values of the corresponding equalizations shall be indicated.

g. GENERAL MECHANIC STRUCTURE

All switches, pilot lamps, control sockets and other operator's controls shall be very accessible after opening of the distributor's door (and) the swing frame in the distributors.

The lettering of the radio plant shall be undetachable and unmistakable. The indication also shall be in accordance with the documentations.

The equipment, which is necessary for signal conditioning, shall be situated in the maintenance Niches and Cabinets in the tunnel tube and in the equipment room. They shall be located in cabinets.

5. Details and Specifications of Devices

a. FREE FIELD RADIO SYSTEM

The complete transmitting and receiving devices of the free field area radio system shall have an adjustable output power (1W -10 W). The minimum responsivity shall be 0.4μV for 20 dB S+N / N and measured with CCITT filter.

The free field area radio shall be designed in that way, that no disturbance may occur between the tunnel radio system and the free field area radio system.

The transmitting and receiving device shall be delivered with all cable coupling and connectors.

The device shall be situated in distributors in the equipment room building.

b. TUNNEL RADIO TRANSMITTER

The complete transmitting device shall have an output power, which guarantees the required minimum responsivity in the tunnel.

The Contractor shall deliver the transmitting device shall including all cable couplings and connectors.

c. TUNNEL RADIO RECEIVER

The exact size of the frequency band depends on the used system (which shall be defined in

accordance with the client). The radio receiving device shall support the services for those frequency bands.

The receiving device shall be delivered with all cable couplings and connectors.

d. COMBINER / DIVIDER

The interconnection of all signals to and from the tunnel antenna system shall occur in a corresponding connecting network with filters, directional couplers, isolators, separating filters, etc.

The changes of the frequencies at the connecting network shall be easily to do.

e. COMBINER TUNNEL TRANSMITTING PLANT

All Tunnel transmitters shall be interconnected by a combiner, so that the occurring intermodulation products are at least 60dB beneath the amplitude of the smallest useful-carrier. If the intermodulation signal meets a fundamental frequency of a tunnel receiver, this signal even not shall make the tunnel receivers operating.

Simultaneous operation of all radio service shall occur without influencing of each other.

The combiner shall be modular and easy to maintain and service. All tunnel radio transmitters of the radio plant shall be able to be combined and supplied into the radio transmitting system. This shall be able for all channels.

f. COMBINER / DIVIDER TUNNEL RECEIVING PLANT

The signals, which were received by the tunnel antennas, shall be divided by suitable actions to the responding receivers.

Intermodulation problems and disturbing interferences shall be avoided.

The divider shall be modular and easy to maintain. All HF-signals of the radio transmitting system plant shall be able for spreading them to the tunnel radio transmitters.

All necessary equipment and material for installing the combiners and dividers shall be included in the price of the tunnel radio system.

g. LOW FREQUENCY PREPARATION

The equipment for low Frequency Preparation shall be equipped as approved.

These preparations include all necessary functions and equipment, which are required for faultless operation / combining and dividing of LF- signals, as eg combination, dividing, amplifier, mixing amplifiers, distribution amplifier, frequency response equalization, galvanic separation, overvoltage protection, etc.

Interfaces shall be foreseen for to:

- Transmitting and receiving devices
- Talk function at the desktop station in the equipment Room and the Control Centre

All equipment, which is necessary for those functions, shall be suitable equipped for the required channels.

h. WIDE BAND AMPLIFIER CONFIGURATIONS

The amplifiers are for terminal the leaky feeder cable and transmitting the transmitting and receiving signals. The amplifiers shall be made with the latest wide band technology (band width 68 MHz – 470 MHz) / as applicable.

The amplifier shall not cause disturbing signals by intermodulation, combination, etc. which:

- fall below a span of 8 dB in the connection of stationary station to mobile stations (span of usable carrier to unwanted noise signal in the suable wide band of as channel).
- fall below a safe clearance of 23 dB in the connection of mobile station to stationary stations (span between usable carrier to unwanted noise signal in the usable wide band

of a channel).

- are less than 20 dB smaller than the smallest usable carrier in direction of stationary mobile station and an unusable signal.

The noise factor of the amplifier shall be not more than 8 dB.

The power supply occurs with 250V / 50Hz. An energy supply via the leaky feeder cable is not allowed.

The degree of protection of the amplifier shall be IP 54. The amplifiers shall be situated in the cabinets.

i. COUPLING UNIT

The coupling units are for electrical disconnection of the signals of the leaky feeder cable, which were supplied from both ends of the cable. But only in case of breakage, the coupling units shall be activated.

They shall be mounted directly on the ceiling of the tunnel between the both parts of the leaky feeder cable. The coupling units shall be covered with shrinking tubes, for protecting them against the tunnel atmosphere.

A low frequency sound signal, which is produced by a cable monitoring unit, shall be injected into the leaky feeder cable.

The telecontrol system uses this sound signal as indicator for the monitored parts of the leaky feeder cable. It indicates disconnections of the parts of the leaky feeder cable.

In case of a fracture (open circuit) or short circuit of one section of the leaky feeder cable, both parts of the leaky feeder cable shall be interconnected via the coupling unit.

In the coupling units are two coaxial relays, which couples the two sections of the leaky feeder cable. With this method also in the immediate area of the location of breakage, a radio operation shall be possible. The cable monitoring unit generates the malfunction information of the corresponding segment.

j. HIGH FREQUENCY OPTOELECTRIC CONVERTER

HF opto electric converter, depending on the requirements, are used as transmitter or receiver. All equipment which is necessary for transmitting / receiving shall be included in the price of the Tunnel Radio System.

The HF optoelectric converters are necessary for the low noise transferring of HF signals over single mode fibres.

The converters shall be connected by SC terminals at patch field. The converters shall be able for installing in cabinets.

Technical requirements:

- Frequency Band: 50MHz -1GHz
- Optical Fibres: E9 /125
- Potential Free Malfunction Contact

k. DISTORTION FACTOR

The distortion factor over each feasible connection in the system shall be maximum 10%, if the HF level is high enough.

l. SYSTEM VALUES

The Contractor shall calculate and measure all values of the radio system. Thereby also those frequencies, which are announced by the client, shall be proofed, if they are free of intermodulation.

If they are not free of intermodulation, the Contractor shall arrange corresponding actions, to guarantee an operation, free of disturbing.

If, because of physical reasons, a mixed product may not be avoided, the Contractor shall already point at it in the offer!

m. LOW FREQUENCY INTERFACES

For avoiding crosstalk on the LF cables, the cables of the radio plant shall be supplied with -6 dBm maximum.

If there is no other prescription, the value of -6 dBm shall be a specified value for the handover of LF levels to foreign of feeders.

- The output level of the radio plant shall be: -6dBm at 600 Ohm (±0.5 dB)
- If Speaking into the microphone: At 1.07-1.1 Pa sound pressure and frequency of 1 kHz
- Noise Voltage: The noise voltage shall be less than -46dBm, if there are no LF signals on the cable.
- Line Attenuation: The radio plant shall be able to equalize cable lengths up to 10km, so that a frequency response with its tolerance after 1 / 5 CCITT may be kept.

n. Equipment For Plant- Inspection

Channel processing test sockets shall be foreseen at the LF interfaces of each channel processing unit. At these sockets, the actual levels can be measured. These measurements shall be made during operation without disturbing the radio plant. For testing purpose, the ability to disconnect the LF course at the test sockets shall be given. So, it is possible, to substitute the input signal of the plant with the test signal.

At the location of the handover from the radio central unit to the tunnel antenna system, test sockets are also necessary and shall be provided by the Contractor. The signals from and to the tunnel antenna shall be decoupled by directional couplers. Therewith it shall be avoided, that the levels at the tunnel antenna are influenced, at the test sockets in case of a level measurement.

At the test outputs the corresponding operation levels shall be described.

The power supply of the whole radio plant shall occur with 250V, 50Hz by UPS.

For supplying the distributors of the Tunnel Radio System in the equipment Room, these voltages shall be provided: 1 x UPS and 1 x Normal supply for the test sockets.

The number of plug sockets depends on the number of devices, which shall be plugged in. These plug sockets shall be fused with own circuit breakers.

The power shall be controlled by these criteria:

- Triggering of main fuse in tunnel radio system distributor
- Loss of internal power supply (each voltage shall get an own information signal)
- The circuit breaker of the plug sockets shall not be controlled.

All signals shall be transmitted as potential free two-way contacts to the tunnel control system.

For all parts of the radio plants (radio central unit and tunnel antenna system) which are situated at the equipment Room or EM niches / cabinets shall not be supplied by coaxial cables. Not even parts of the radio system shall be supplied by coaxial cables.

o. OVERVOLTAGE PROTECTION

Cables, which are coming from the free field area and run into the radio system into the tunnel or into the equipment room, shall be protected against overvoltage.

Low frequency cables shall be equipped with isolating transformers which have a voltage endurance up to 2.5 kV. This protection consists of a combined protection against longitudinal and transverse dimensioned in accordance with the respective operating voltage.

Overvoltage protection devices shall be installed by using plug connectors with suitable terminals at antenna cables in the free field area.

6. Tunnel Antenna - Leaky Feeder Cable

a. In the main tunnel tube, a leaky feeder cable shall be used as antenna.

b. It consists of a coaxial structure with gaps or slots in it, with a regular span in its outer conductor for radiating or receiving signals along its entire length. Those gaps / slots ensure repeating coupling and decoupling of the energy. Furthermore, the leaky feeder cable shall have a flame-retardant sheath as per IEC 332-1, 332-3/C, 754-2 and 1034.

c. The leaky feeder cable shall be executed for 50 ohm and a frequency band of 60 – 500 MHz.

d. The section of the leaky feeder cable shall be supplied with a wide band amplifier in a T-system (in the tunnel tube to the accesses) and in a L- system (from the equipment room to the tunnel portals).

e. For transmitting and receiving of the frequencies in the tunnel tube two leaky feeder cables shall be foreseen. One is for TX- signal and other one for RX -signal.

f. A disconnection of the leaky feeder cable shall not stop or interfere the operation of radio. Each amplifier of the Tunnel Radio System shall supply leaky feeders with a length of maximum 625 m to the left and right side. If the leaky feeder cables will be squeezed or pinched off, the radio connection from the amplifier to the sectioning point shall be sustained.

g. Depending on the installation site, the cable shall be mounted with cable holder, spacer, cable clamps. plain washers, and so on. The span between the fixings shall be 1.0m. Additionally to the common fixings, fire proofed cable clamps, made of stainless, shall be installed in an irregularly span (between 8 m and max.12 m).

h. The course of the leaky feeder cable shall be straight.

i. In those areas, where shotcrete is used in the tunnel, first a steel wire rope shall be fixed on the ceiling. Onto this steel wire rope the leaky feeder cables shall be fixed. Therewith the unevenness of the tunnel ceiling shall be levelled by using corresponding spacers, so that the steel wire rope runs straight. If required, the steel wire rope shall be included in the price of the leaky cable.

j. The instructions of the cable producer and the Indian standards, which accord to the installation of the leaky feeder cable shall be considered. Furthermore, actions for mechanical protection (e.g. guide roller) shall be used. It is not allowed, that the cables were pulled on the blank concrete, edges, etc.

k. The leaky feeder cable shall be mounted on the roof of the tunnel tube.

l. The leaky feeder cable, which will be used, shall be appropriate for using in tunnels and it shall operate independently of environment influences. it shall be resistant against the tunnel atmosphere (salt, temperature change and humidity), as well as mechanically and chemically stresses insensitive.

m. Terminal resistors, which are situated in the tunnel tube or accesses, shall be made moisture proof with shrink tubes. Those shrink tubes shall be coated with adhesive inside.

n. For transmitting of control signals, the leaky feeder cable shall not be used. The power supply must not run through via the leaky feeder cable.

o. The values of the cable, as line and coupling attenuation, shall be coordinated to the whole system. The functionality of the whole system shall be verified with calculations. These calculations shall be handed over to the client.

7. Antenna Column

All free field area antennas shall be situated on the antenna column. The height of this column

shall be 25 m The column shall be fixed on a foundation and the material shall be made of galvanized steel tube. Further the antenna column shall include a safe climbing system with fall protection ladders.

Safe Climbing System

The safe climbing system with fall protection ladders (Y-spar ladders), made of light metal which suits to the antenna column. Also a leading system for the cabling along the column shall be covered at the lower part (the first 3 m on the column from the bottom) by a lockable covering, so that a climbing or damaging of unauthorized people will be avoided. The keys for the lockable covering shall be handed over to the client. The span between the footsteps shall be 500mm. The rung spacing shall be approx. 300 mm.

The safe climbing system also shall have a top and bottom end stop.

The safe climbing system shall be erected from the foundation of column up to masthead.

Additionally, to the safe climbing system with fall protection ladders a staff protective equipment shall be delivered. This staff protective equipment shall fit to the safe climbing system. it shall include at least a safety harness and a quick adjusting manual rope grab with shock absorber. A vertical lifeline shall be connected to an anchor point.

The antenna column shall have a protection against lighting. Therefore, a lightning rod shall be provided, and the Contractor shall connect all metallic parts with the earthing system.

All cables along the column shall be installed by C –section rails, which are separately fixed with cable clamps. The C – section rails shall be fixed permanently with spacer in a span of 50 cm.

The location of the antenna column shall be near the equipment room / control room. The exact location depends on the results of the measurement. The Contractor shall deliver static calculations for the foundation, the column and the mounting structures of the column. The calculations shall be handed out to the client.

All costs, which are combined with the delivering and mounting (also for the foundation) of the column, shall be calculated into the price of the tunnel radio system. Also the total erection and the static calculations of the foundation and the antenna column shall be included in the price of the Tunnel Radio System.

8. Free Field Antennas

Directional antennas for the corresponding frequency band shall be provided and installed. The antennas shall be designed as a professional type inclusive of protection against icing.

- Frequency Band: 68 - 470 MHz
- Polarization: Vertical
- Antenna Gain: Approx. 15 dBi

The mounting, alignment and installing shall be included in the price of the tunnel radio system.

9. Desktop Station

In the control rooms desks in the equipment Room and Control Centre Desktop Stations for the Tunnel Radio System shall be installed. The functionality consists of listening and talk function for the individual channels.

The Tunnel Radio Desktop Station shall be modular and for all Channels. It shall be easy to operate and maintain. It shall consist of a handset, “gooseneck microphone”, a loudspeaker and push button key pad with a control display. This display shall indicate the status of the various channels. The transmitting shall talk with the desktop station into the Tunnel Radio System. Also, the possibility to play text conserves shall be given. Different pre-recorded messages (amount and text message shall be defined in accordance with the client) shall be stored.

The Desktop Station for Tunnel Radio System also can be used for the public address system, if required.

All necessary equipment shall be included in the price of The Tunnel Radio System.

5.2.16 Emergency Call and Service Telephone System

1. General

According to IRC SP99 an emergency telephone system shall be installed for dispatching information regarding the occurrence of an accident to the Central Control and the Authorities, by person involved in or discovered the accident. Telephones shall be installed at intervals of 150 m, and in every relevant area of the tunnel (cross passages, Layby etc.). Emergency Pushbuttons to be activated by person involved in or discovered the accident shall be provided along the tunnel at intervals of 50 m.

An emergency telephone is a phone specifically provided for making calls to emergency services and is most often found in a place of special danger or where it is likely that there will only be a need to make emergency calls.

Whenever road user needs to contact control room in case of an accident or emergency, he will just lift the handset and call will be get connected to control room. Location from which user is dialling will also be indicated in control room. Voice over IP emergency telephone shall be used to communicate with the operation and maintenance centre. In these devices, a location identifier is also transmitted. The signalling and voice transmission is handled with the VoIP standard protocols, SIP / SDP (Session Initiation Protocol) and RTP (Realtime Transport Protocol). The driver initiates a call by lifting the receiver. Until the operator in the OMC answers the call, a message to wait and keep calm is being presented to the driver. Once the call is established, the driver and the operator can speak to each other. The call can be ended by the operator or the driver, who has to put down the receiver.

2. Scope of Work

The emergency and service telephone system includes:

- Intercom-Stations
- Telephone Central Unit
- Desktop station
- Emergency call stations
- Service telephone stations
- Cabling

All equipment shall be designed and manufactured for an operation 24 h each day.

3. Technical Specification-Emergency Call and Service Telephone System

a. The hardware of emergency call system shall be situated inside distribution panels.

b. The EPC / EM Contractor shall guarantee that functionality for emergency system shall be sustained over the whole tunnel length. The emergency telephones shall provide a reliable voice connection to the control system in case of an incident. The emergency call stations shall be built up very user friendly. On one hand, the emergency telephones are needed to grant persons in the tunnel an immediate connection to the Control Centre in case of emergency. On the other hand, along the whole tunnel as well as in the equipment rooms are also service telephones situated. These telephones are required for maintenance staff. The emergency and service telephones shall be combined in one system. They use the same transmission cable, but for the emergency system an immediate connection to the Control Centre must be given. The emergency call has a higher priority than a service call! The optical fibre ring shall run over switches.

c. In these switches optical fibre electrical converters shall be included. All telephones, that

means the emergency and the service telephones shall be connected directly to those switches via RJ 45 plug-in connections. The intercom stations (emergency call central unit master and slave) at the equipment Room / Control Centre shall manage the telephone calls of the whole tunnel. So, the intercom station at the Equipment Room / Control Centre also shall initiate the distribution of the calls. That means, if an emergency call arrives, the information shall be prepared for transferring it to the control system via TCP / IP, because the main operation and receipt of the emergency call Shall be at the Control Centre. But also, in the Equipment Room desktop call stations, visualization and operations shall be possible. The intercom station shall be the interface to the Contractor of E&M. The Contractor of E & M shall take the information from the intercom station and shall transfer it to SCADA.

d. Furthermore, the tele control system shall enable the operation of these calls. That means, the emergency call's information shall be shown at the operator's screen and different functional processes shall be activated as described in Tunnel Control and Instrumentation System"

e. If a service telephone call arrives, the system shall check if this call is determined for the external (public) or internal telephone system. A distribution to the external (public) telephone system occurs via a Telephone Central Unit.

f. Generally the transmission of the whole emergency and service telephone system shall occur via intercom station at the Equipment Room / Control Centre. But if an optic fibre ring is interrupted, or a failure at any device is detected the system shall find an alternative route via the intercom station at the equipment Room / Control Centre. The required reaction and information transmission although shall be kept in permitted time. The operator in the Control Centre must be able to communicate with the person at the emergency telephone within a time of 3 sec. after the set of the emergency' call.

g. The Contractor shall guarantee, that even after a long break down of the power supply / the IP addresses of the telephone call system are not gone lost (whether emergency call nor service telephone system).

h. The telephone system shall be free structure programmed and scale able.

i. If somebody presses the push buttons at the hands-free speaking device at the emergency call station, immediately a visual and audible alarm shall be initiated at the equipment room and Control Room, and automatically all predefined functional processes shall be executed.

j. Apart from the information of speed also the information of failures shall be transmitted during an

k. emergency call. If a failure is detected (short circuit, interference voltage, etc.) the other parts of the system shall be untainted.

l. When the push button at the emergency call station is pressed, the voice connection - shall be initiated automatically to the tunnel operator at the Control Centre. As long as the emergency call is not answered by the operator, a pre-recorded text conserves shall be played (e.g. "your call is being answered soon, please stay calm" or similar). The exact messages shall be defined in accordance with the Client's instruction & requirement. Even the language (Hindi and or eventually English) shall be defined in accordance with the Client.

m. The voice communication between the operator and the fugitive shall be ended only if the operator disconnects.

n. Since the emergency call stations do not have a handset and that the tunnel is also used by maintenance personnel & others, it is necessary to ensure a good understand ability ("audio quality") although a hands-free speaking system is used. Also the volume shall be adjusted to the environment manually during initial operation.

o. The expandability for data transmitting shall be given. All push buttons and cabling shall

be cyclic monitored. The zero-signal current also shall be monitored. If any failure is detected, fault signals shall be transmitted.

p. With the signals of emergency system no activation of any fire-programmes are allowed.

q. The maximum time, which may pass from the moment when an emergency call is set up till the operator answers the call, is 5 seconds.

r. The complete emergency and service call system shall be supplied by the UPS-System, so also in case of main power break-down the call system (especially emergency call system) keeps functioning.

s. The whole cabling from the distributor to the consumer shall be installed by the EPC Contractor (Telecommunication).

4. Emergency Call Station (Voip)

a. Emergency telephones shall be a single-line set, mounted in the emergency call cabinet of the Niches (with E&M equipment's), Maintenance room panels and in the Emergency Call Cabinets at the portals and Accesses.

b. Emergency telephones shall have a hands-free-speaking system. The emergency call will be activated by the fugitives with a push button. The push button shall be integrated in the front panel of the hands-free speaking system, so that they are very easy to press in case of emergency.

c. Only speaker, microphone and the push button of the emergency call system shall be mounted in the front panel of the emergency cabinet, so in case of communication, it shall not be necessary to open the cabinet. The rest of the emergency equipment shall be situated inside of the cabinet.

d. A two-way voice communication is necessary, so that the people can tell the operators about their situation in the tunnel, as well as the operator can calm the fugitives down and give them important instructions. The emergency call stations shall be resistant against the tunnel pollution (exhaust gases, smoke, etc.) as well as against the humidity ('weather proof type", IP 65) inside the tunnel tubes.

5. Emergency Telephones (Ip-Telephones)

a. IP-telephones shall include a microphone, a loudspeaker, a push button, etc. The protection shall be at least IP 65, the power supply 24 V-42 V AC. Further they shall contain 2 potential outputs and 2 inputs for potential free contacts.

b. The values are valid for emergency and service telephones. Hands-free speaking system shall be connected directly with the switches, by a suitable device. Emergency call stations throughout the whole tunnel shall be indicated via illuminated signs, mounted on the tunnel wall above the emergency call station. Size of these signs shall be 470 mm x 470 mm. The symbols of the illuminated signs shall be visible in both tunnel directions. These signs also shall be supplied by the UPS. But the signs and their cabling will be erected by the Contractor of E&M.

6. Intercom Stations

a. In the Control Room, master and slave intercom stations shall be placed. These stations execute the same function as a "Telephone System Server". On one hand these stations shall screen all calls of complete telephone system and on the other hand they are the interface to the transmission of the emergency calls to the tele control system and further on to the Control Centre. This transmission shall occur via TCP/IP. The service telephone calls shall be transmitted to the Telephone Central Unit.

b. The intercom stations shall be equipped with an interface to the tele control-system, so that automatic programmes can be initiated- for example, if an emergency call is initiated activated / the nearest camera will be connected / switched to the emergency video screen at the operators place automatically.

c. The intercom station shall be equipped with different modules. The modules are for preparing an interface to the SCADA, to the external (public) telephone system, desktop call station. Each module can operate no. of telephones.

d. The operating system of the emergency call system shall be realized with high-level language, but it also shall be object orientated. The operating system shall be stored in a Flash prom, so that a changing of e.g. EProms is not necessary for updating the operating system.

e. The following cards are required for the Intercom Station at the equipment Room / Control Room:

- Participant-cards TCP/IP for no. of participants
- Participant-card for connecting the desktop call station
- Network card ISDN with one basic terminal
- Network interfaces
- Digital audible coupling- and recording-card

f. The following cards are required for the Intercom Station at the equipment Room:

- Participant-cards 2-wired for no. of participants
- Participant-card for connecting the desktop call station
- Output card for relays, potential free
- Network card
- Network interfaces

g. Following features are required at the intercom stations:

- System Functions: 1-8 digit telephone numbers (also mixed), Frequency 300 Hz -16 kHz (analogue), feedback-protection, selective locking of features
- Voice Control: conversations in Open Duplex, Duplex or Simplex/ Volume separated adjustable for different functions
- General Conversation Functions: automatic conversation set-off for each participant; different pre-recorded messages (number and text shall be defined in accordance with the Client); discreet-function; locking of microphone function; ''occupied"-function; priority call function; call-back-request; connecting with other participants; retrieving of last call; speed dial for all participants, or separated for each participant; priority function.
- Functions with additional Interfaces: adapting with telephone-dial-devices/ output contact for system functions
- Group-calls
- Teleconferences with any participants, and predefined participants
- Audible transmitting of alarm inclusive an alpha numeric display
- Desktop call station: selecting of a set-up between service- and emergency-calls; displaying wait-information after set-up of a call, wire-detection for telephone stations, output-contacts for service- and emergency calls/ group-contacts for calls, manual calls - switching, automatic call-switching of calls depending on time (night I day), texts for display, changing to communicate via more desktop call stations at same time
- Bidirectional communication to control system
- Tests of functionality: periodic tests by testing loudspeakers and microphones / monitoring of wiring of call stations and their inputs, monitoring of network

h. SCADA generally shall process all emergency calls.

i. In the Control Centre also a desktop call station shall be situated. Therewith the operator can communicate per voice with the people at the emergency call stations very easily. Also, communication with the service telephones shall be possible with this desktop call stations. Those desktop call stations shall be connected to the Intercom Stations in the Equipment Room and Control Centre.

j. Each emergency call causes a visible and an audible alarm in the Control Centre, so the operator is immediately warned. Furthermore, the exact location of the incoming emergency call shall be Visualized on the operator's screen (tele control screen).

k. The operator may switch between different calls and sets up a connection from the Control Centre to any emergency station.

l. The complete emergency call system also surveillances itself, so malfunctions shall be kept to a minimum. The system shall also check itself for interruptions of connections due to wire breakage or open circuits. If such a failure is detected, the failure shall automatically be notified & sent to the tele control-system, where maintenance messages for the operator will be generated. So, failures will instantly be detected and can be repaired rapidly.

m. A further function of the Intercom Station regarding to the Service Telephone System is to provide a connection from the internal service telephone system to the external (public) telecom system with the Telephone Central Unit. The intercom station transmits the calls to the Telephone Central Unit. There it will be prepared and transmitted to the external (public) telecom system.

7. Voice Recorder

A voice recording system shall be linked with the Intercom Station in the Control Room Building. There all emergency calls (not the service telephone calls) shall be recorded and stored automatically. Since ·it is required to store the emergency conversations this digital voice recorder shall be able to record all emergency calls simultaneous. Also, the possibility to hear the calls to a later time again must be given.

Table 12: TECHNICAL DATASHEET OF VOICE RECORDER

Frequency	20-6800 Hz
Distortion factor	0.2 %
Interference voltage span	-70 dB
Maximum possible storage time	360 seconds for each emergency
Call Hard disc storage for voice recording	80MB
Resolution	12 Bit linear
Recess frequency	16kHz
Output	0.2-2V/200 Ohm

8. Desktop Call Stations

a. The handling of emergency and service telephone calls by the operator shall occur via a desktop call station. With this station, the conversations shall be administrated, the inputs displayed and the outputs shall be controlled. The system of the desktop call station has to build up fully VoIP-digital and connected with corresponding interfaces to the intercom station.

b. This desktop station shall include a loudspeaker, a "gooseneck-microphone" and a keyboard with functional keys for talking, clearing, volume, etc. The possibility for digital

monitoring of loudspeaker and microphone of the desktop call station shall be given. The display shall have a suitable resolution and number of rows and signs.

c. The individual desktop call stations shall have the possibility to operate parallel. The individual functions of the desktop call stations shall be able to be combined with each other. Also, the sequences of the incidents shall be displayed. The incidents have to cause an audible signal at the desktop station. A failure-key shall check all functions of the desktop call station. The individual function keys shall have status. LEDs.

d. All executed control functions of the desktop stations shall be transferred to the intercom station. The Desktop station shall be supplied by intercom station-with signals.

9. Service Telephone System

a. The Service Telephone System shall include telephones at the equipment room/ Substation/ control room. These telephones shall provide a possibility for voice communication for the maintenance staff. Because the service telephone and the emergency call system are combined, it shall be guaranteed, that the priority always shall be by the emergency call.

b. The service calls do not have to be recorded and stored like the emergency calls.

c. The Service Telephone System also shall have an outline to the external (public) telecom system (this outline will be erected by others, but the module therefore shall be provided by the EPC /EM Contractor of Telecommunication System) .

d. The system shall guarantee that calls from the substations can communicate directly together without exchanging through the central unit. This means the possibility of direct connection among each other shall be given. The transmitting of the service telephone calls to the external outline shall occur by a "Telephone Central Unit''. This connecting equipment shall distribute the telephone calls.

e. Additionally, the possibility to dial from the substations through the outline to external telecom system is required. But for every substation this function shall be separately adjustable (locked I unblocked).

f. The functions are also required:

- Pick up of an internal or external call from every substation
- Call diversion to every substation
- Conference call
- Call diversion in the night to a certain telephone, or a certain outline.
- Blocking of out callings
- Creation of authorization levels (max. 3) for different kinds of callings (only internal callings, all callings, etc.)

10. Main Telephone Apparatus (Ip Telephones)

This telephone shall be positioned at the operator's desk. The handset shall be impact-resistant, made of plastic, coloured as required by the Client. Further it shall consist of a rectifier for hearing protection and a cord. But the operator even may communicate by the desktop call stations.

The telephone keyboard shall consist of phone buttons, speed dial keys, a display with at least 4 rows (as required to suit site requirements) and status LED next to the function keys.

This apparatus shall ring with a volume of at least 65 dB.

11. Telephone Sockets

The telephone sockets shall be mounted on walls or in distribution panels. The sockets shall be RJ45 type. The housing shall be impact resistant, made of suitable material and the colour as required of the Client.

5.2.17 Public Address System

A. Design Requirements

a. SYSTEM DESIGN

The design for the Digital Public Address/Voice Alarm System should meet the user and system requirements below.

b. USER REQUIREMENTS

The broadcasting system uses the same device to play the emergency broadcast. It has an emergency call microphone in the fire control centre for evacuating the crowds in specific zones when accidence happens and a paging microphone in the broadcasting centre to broadcast announcements and search notices.

The broadcasting devices located in the broadcasting centre or the specified location according to the user's requirement. The placement of the devices should meet the operating environment requirement and save up floor space. The amplifier capacity should comply with national standards and be with redundancy. Meanwhile, the emergency broadcast can achieve the linkage of the adjacent layers. Users can select the layers to be linked.

c. SYSTEM DESIGN REQUIREMENTS

The global mature and advanced technologies are critical for designing the public address system and only the broadcasting system incorporating mature and industry-leading technology and high-technology products can ensure the intelligence for buildings.

In the system design, advanced concepts, technologies and methods need to be adopted; system structure, product designs and wiring easiness also need to be considered.

d. FUNCTIONALITY AND RELIABILITY

Besides the technical advancement mentioned above, functional design, system structure, system performance, manufacturing process and after-sales support are also important as to ensure the reliability and stability of the system operation, maximizing the mean error-free time.

A mature technical platform and the rigorous manufacturing process are the bases of functions' realization. During the runtime, system should be able to discover and eliminate all the functional faults in time. The core components can achieve auto backup. System administrators can easily access the failures and work logs.

e. SYSTEM FUNCTION - SYSTEM DESIGN COMPOSITION AND PRINCIPLE

The system has placed broadcasting devices in Tunnel. The distributed control device (DCS) is integrated with many functions and supports the connection via Ethernet. It has loudspeakers output circuits to connect the loudspeaker in zones and network connection interfaces to connect to network paging control panel via Ethernet. Each DCS can connect up to 4 amplifier channels. The device has integrated amplifier switching matrix to support the redundancy switching and the general dry contact input/output interface to connect the external audio sources and dry contact interface of the linkage fire system. It has a built-in 1G memory to store the audios such as digital voice messages and the alarm tone of the emergency broadcast. This device can operate independently without the PC. It encompasses the functions like the audio playing, zone control, fault monitoring, log recording, volume control and amplifier switchover.

The control device for the system is customized. It has the LCD touch screen for operations, like zone selecting, calling, audio sourcing selecting, and emergency broadcast, monitoring and internal communication. The functions of the Programmable network paging console NPM can be configured using the configuration software.

f. KEY FEATURES -DISTRIBUTED CONTROL

This distributed design for the system is based on the tunnel profile to facilitate the

connection of the loudspeakers in several nearby zones, which will make the control of the loudspeakers easier. The selected system devices should use the TCP/IP technologies and build on the standard network platform to ensure the extensibility, compatibility for multiple technology platforms and advancement of the system.

g. FAULTS DETECTION AND ISOLATION

The Faults detection function for the broadcasting system can automatically examine the host system, power amplifier, power source, communication, and detect the open circuit, short circuit and grounding fault to generate the fault alarm and log.

When the grounding fault or short circuit occurs, the amplifier or the main controller of the system should isolate the circuit to ensure the operation of the main devices and normal circuits.

h. SERVICE BROADCASTING

The paging microphone allows users to make paging and broadcast search notices by zone. The paging microphone has a colour LCD touch screen. Users can configure the functions directly on the screen. Users can select the zone and audio source, adjust the volume, and enable the emergency broadcast by pressing the button on it. Paging microphones can intercommunicate. 255 broadcast priorities levels available. When the connected distributed control unit is out of order, a paging microphone can continue the intercommunication with other microphones in the network and precede the remote broadcasting configuration on other control units.

i. TIME SYNCHRONIZATION

Within the system, the controller can specify any main device as the main time source or choose a third-party system to be the time source. Other devices synchronize their time with the main time source to make sure the time is consistent in the system.

j. EMERGENCY BROADCAST

The broadcasting system can be linkage of the fire system to achieve the alarm function in the adjacent layers. The layers for linkage can be configured with the software as the requirements. Users can record the voice message for the emergency broadcast and save it in the host system. The emergency broadcast can start automatically (when linkage of the fire system) and manually. The broadcasting system has its own emergency microphone, which could be used to play emergency broadcasts and evacuate the crowds in specific zones.

k. AUTOMATIC AMPLIFIER SHIFT

The system has standby amplifiers. When a main amplifier fails to function, the standby amplifier replaces it automatically. After the main amplifier recovers, the system will use it instead of the standby amplifier in an automatic way.

l. BROADCAST RECORD

The DCS can record sufficient voice message (up to 1GB), and its contents can be customized. The voice message contains the emergency broadcasts for fires, such as evacuation and all-clear information, which are played by the digital speech synthesis system automatically (linkage of the fire alarm system) or manually. Four languages for the voice message are available. Users can select one of the languages to record the information.

m. LOG

The system can record the device fault log and operation log. Users can search information in the logs using time, devices, operators and log types as search criteria.

n. POWER SOURCE FORCED SWITCHOVER

The key devices, like DCS and amplifiers, have main power source and 24V standby power source. When the main power source fails to function, the standby power source is

responsible for the power supply.

o. DISTRIBUTED CALL STATION

The distributed call station can call the specified zones. The call station has remote control function, which can control emergency broadcast, zone audio sources and external devices.

p. AUTOMATIC VOLUME CONTROL

The volume of the system can adjust automatically responding to different levels of environment noise in the crowded areas.

q. LOCAL & REMOTE MONITORING

Users can monitor audio sources status via local distributed control units and remote call stations.

r. EMERGENCY BROADCAST - Emergency broadcast Requirement:

i. Forced Switchover (Auto/Manual): Once the emergency broadcast is triggered by a remote-control microphone or other external devices (fire alarm system) the system will play the recorded voice message (alarm and evacuation information) for fire emergency or the information from the emergency microphone until the all-clear.

ii. The system will switch to emergency broadcast in 3 seconds.

iii. The signal tones and voice messages (alarm and evacuation information) of the Emergency broadcast system are stored on the voice storage flash or SD card, which will not be ageing or lost. Users can play them in all zones.

iv. Emergency broadcast system should have system testing function as a standard configuration. The testing for the system can enable the operator to ensure the normal operation for the system all the time. The testing of emergency broadcast should be enabled via the software instead of playing the actual emergency broadcasts and causing public's panic.

v. Emergency broadcast system should achieve the automatic amplifier shift. Once an amplifier fails to function, the standby amplifier replaces the breakdown amplifier automatically without changing the input and output circuits of the amplifier manually.

vi. Emergency broadcast system should have pre-recorded emergency broadcast messages. The system should be able to edit and record the alarm and evacuation message. The priorities of the emergency broadcast can be programmed. DCS should be with a PTT emergency microphone, with which operators can announce real-time evacuation notices when emergency happens.

vii. Users can listen to stored or audios about to play to avoid playback error message which may lead to crowd panic.

viii. Language kinds should meet the user's requirements. There should be spaces left for the tags to facilitate users to stick related prompts for management.

ix. The system can automatically record voice messages sent by emergency microphone. Users can listen to and broadcast voice messages.

x. The linkage signals of the emergency broadcast uses the volt-free contact. All signals are from the fire control Centre. The number of cables is the same as the fire control Centre number.

xi. Can achieve the linkage of the adjacent layers. Users can select the layers to be linked via software configuration.

xii. When system switches to fire alarm mode, fire floor plan will pop up in the operating interface, directly showing where the fire happens. Operators can select specific zones and activate the warning and evacuation broadcast on the operating panel.

xiii. The loudspeakers allow the 3-wire forced volume control switchover.

s. CIRCUIT DETECTION

It is able to detect every zone's status to ensure the working order of the circuits and report faults in time. When a short-circuit error takes place, the device isolates the zone where error happens to protect the amplifiers and to cut off its impact on other zones.

B. Functional Requirements

a. DEVICE SELECTION

The system should be based on the TCP/IP network technologies with high level of integration and flexible configuration to meet various requirements. It is designed for the emergency broadcast enabling fire emergency broadcast functions like automatic fire warning, voice message pre-setting, emergency calling, emergency call recording and circuit monitoring. The device is accordance with the Automatic Control System for Fire Protection (GB16806) and Standard EN 54-16, IS-11360

With public address and voice alarm system integrated into one, the system should solve the duplication of investment and security risks and other problems caused by two individual systems. The distributed intelligent systems should be capable of accessing the 10/100M Ethernet network and multiple audio sources from the network. It supports connections in the Ethernet and the networking for several other control systems to perform centralized and distributed management via software. This product should be suitable for medium-scale and large-scale requirements

b. TECHNICAL CHARACTERISTICS -HIGH INTEGRATION

The controller should be able to integrate audio source storage, network audio reception, voice broadcasting, audio matrix, volume control, and monitoring, troubleshooting and main/standby amplifier switch functions together.

c. SAFETY

The system should be GB16806/EN54-16 compliant and can work in severe environment. It can be used to broadcast in case of emergency to disperse and evacuate people. It is a great guarantee for people's life security

d. ETHERNET BASED EXTENSION

The central controller should be able to connect over the Ethernet without any external device. The configurable Network Paging Microphone could be placed anywhere in the Ethernet, which will enable the following:

- The method of distributed installation can save the cost of wiring.
- If the band width is sufficient, it can use current internal network.
- Provide plentiful network audio sources.
- Centralized management of the system via system software.
- Control the local or global broadcasting by the manner of permissions.
- Easy to upgrade

e. MULTIPLE AUDIO SOURCES SUPPORT

The system supports the audio sources from emergency microphone, network audio, ancillary line input, build-in audio/music files and web microphones.

f. PRIORITIZED CONTROL

The system supports 255 priorities. Users can configure it in any way they want and realize all kinds of prioritized broadcasting controlling.

g. AUTOMATIC VOLUME CONTROL FUNCTION

In places of crowded people and loud noises, users can install a noise detector, which can help control the broadcasting volume automatically to ensure sound's intelligibility.

h. LOCAL AND NETWORK MONITORING FUNCTION

With the built-in loudspeaker of controller or Configurable Network Paging Console, users can monitor each zone's broadcasting. The monitoring volume can be adjusted.

i. TOUCH SCREEN

Programmable network paging console (NPM) is equipped with a touch screen. Users can operate on the touch screen to configure multi-zones settings without the need to extend hardware key modules, saving floor space on the desktop.

j. TROUBLE SHOOTING FEATURE

The ASD troubleshooting technology can support the system to automatically detect the failure of the main power, standby power, amplifier circuit, amplifier protection/power, software, communications and loudspeakers etc. It can also locate the failure for maintainers to repair or replace the fault units.

k. LOUDSPEAKER CIRCUIT DETECTION

The SIM loudspeaker circuit detecting technology helps monitor loudspeaker circuits' statuses. When short-circuit or open-circuit faults are found, the device will send a warning automatically. The software can display all the circuit faults for maintenance's convenience. Usually, a loudspeaker's short-circuit fault will activate the amplifier protection, affecting the working order in other zones. SIM solves this problem by automatically isolate the short-circuited zone where fault is found.

l. AUTO-BACKUP

Risk Free auto-backup technology focuses on realizing the main units', including servers' and amplifiers', backup and switchover functions. A server machine is paired up with a standby one, while a standby amplifier can serve as the backup machine of one, two or three main amplifiers. When faults are detected on the main machines, the system will switch over to the standby one.

m. INPUT/OUTPUT TRIGGERING

This system has input/output interfaces which can be triggered by dry contacts. Engineer staffs can configure the contact input to achieve the broadcasting control by the external device (linkage of the fire system). The contact output can be used to control the external devices for the volume, forced switchover and so on. The contact output interface can be linked of the broadcasting operations.

n. VOICE RECORDING

Besides in the system server, the controller should have 1GB solid-state storage to store the alarm voice, service voice and other audio files. Users need to upload the audio files to the device using the specified configuration software.

o. VOICE ALARM

This system is designed in accordance with the EN54-16 Standard and national standard GB16806. It is full featured for the fire alarm. When the fire occurs, the system will play the pre-set voice information. Then it can play the evacuation information for the zones with fires and the fire alarms for the nearby zones. The system can set several kinds of language for voice information, which can be played using the operation panel.

p. ONE CLICK TECHNOLOGY

To increase operation's convenience, One Click technology is developed with which broadcasting can be started by clicking only one key. The operation shortcut can be configured with system management software and network paging console.

q. MULTICHANNEL DIGITAL POWER AMPLIFIER

Multi-channel digital power amplifiers with CLASS-D technology design should be used in the system. Its output efficiency is more than 80%, which can reduce the power costs.

Besides low power consumption, it is small in size. In this case, several amplifiers can be put in the same chassis to save the space. This kind of power amplifier has the features as below:

i. CLASS-D Amplifier saves the energy with high efficiency.

ii. Channel number can be 1, 2 or 4

iii. 100V or 70V output is used for each channel.

iv. Support balanced input or unbalanced audio input mode.

v. Cooling mode is forced air-cooling mode.

vi. Able to limit output voltage automatically.

r. FLEXIBLE CONFIGURATION

This system allows users to customize the configurations flexibly using the specific software. The engineering technicians and maintainers can configure the built-in audio sources, keys' functions, troubleshooting, audio source play modes, broadcasting priorities and contact input/output and other customized operations the One Click functions. The configuration software for this system is used to configure the hardware. The default configuration for the device contains only the basic functions. Users need to work on each setting, including basic parameters, troubleshooting, broadcast pre-set and key events and so forth.

s. SYSTEM MANAGEMENT SOFTWARE

The system management software can run on the Windows XP/Windows Vista/ Windows 10 or latest operation system. It can communicate with the system via the Ethernet. The operation is as simple as below:

t. SYSTEM CONFIGURATION

- Configure the components and functions of the system management software.
- Configure the devices for the server.
- Configure the electronic map or operation interface.
- Configure audio sources and pre-set broadcasting operations.
- Drag the maps, icons and buttons to modify the layout on the server operation interface.
- Configure the managing scope and authorities for software on the client end.

u. USER MANAGEMENT

It can add, edit and delete users and manage access control of the users.

v. BROADCASTING CONTROL

The broadcasting control function allows users to manage all the broadcasting businesses and to manage the broadcasting management client ends.

w. SYSTEM STATE MANAGEMENT

The software can obtain broadcasting states of each device in the system. The buttons and icons representing devices or zones will be green when all functions are normal, and will turn red when fire occurs.

x. SYSTEM WARNING

System Warning Function allows for centralized management of device failure states in the system and recording the fault log automatically in the log module. When the system detects failure, the interface of the system management software will give out audible & visual alarm. Failed device unit is yellow. Users can accurately locate the failure unit using the interface of the system management software.

y. LOG MANAGEMENT

System can record and store all system operations histories and failure events for future analysis. Work log and failure log will be stored in separate memories and cannot be deleted manually. Only the logs of the latest one year will be stored. Users can query the logs according to time, workgroup, device, etc. and export the result logs.

z. VOICE SYNTHESIS

The system management software provides the interfaces for the third-party voice synthesis software. It can convert the text words into voice for playing.

aa. AUDIO MANAGEMENT

It allows users to perform centralized management of the audio files on the server, and to play them on the network. The audio management function can convert the audio source files in different format into the specified formats of the system. It can put the audio files to the specified broadcasting zones by configuring the pre-set broadcasting operation.

bb. DEVICE DESCRIPTION -DIGITAL INTEGRATED SYSTEM MANAGER / CONTROLLER

The Digital Integrated System Manager is hereinafter referred to as the DCS.

The DCS is the control equipment in the system designed for extending the number of loudspeaker zones, and can support multiple sound source files for broadcasting. The system integrates with functions such as the sound source file storage system, the network audio broadcasting system, the loudspeaker zone control system, and the system for monitoring and diagnosing faults.

The DCS offers various features, which are listed below:

i. Supports the manual selection of sound source files, zone buttons, and can be directly operated.

ii. Supports emergency microphone input for emergency broadcast in the event of, for example, a fire evacuation.

iii. Includes different indicator lights that identify system running states.

iv. Performs remote paging and broadcasting operation through the Configurable Network Paging Console (NPC).

v. Includes 8 zone outputs. The number of zones can be configured through the software.

vi. 4 auxiliary inputs that can connect to external sound source equipment such as a CD player or tuner

vii. 4 auto volume control input ports that can set the phantom power supply and gain of each input.

viii. Auto loudspeaker circuits, short-circuit and open-circuit detection.

ix. A fuse protects the main power supply. In the case of a power supply short circuit within the DCS, the system automatically disconnects the main power supply.

x. Built-in loudspeaker that can monitor the zones and sound sources, as well as monitor the network audio through the NPM / NPC.

xi. Contains 1GB of built-in flash memory that can store recorded voice files so as to full fill functions such as voice information broadcasting and voice synthesis

xii. Can simultaneously broadcast four types of sound sources, such as voice audio sources and external input or network audio sources.

xiii. Can automatically record operation and fault logs, and can store up to 10,000 logs of each log type (operation and fault log types).

xiv. Supports switching between the main and backup power amplifiers, and is capable of configuring the standby mode.

xv. Contains a self-test function.

xvi. Supports automatic fault diagnosis.

xvii. Supports broadcasting volume adjustment.

xviii. Can define the zone and sound source functions. Button function description labels are also easy to install.

xix. An audio matrix enables broadcasting any audio source in any zone.

xx. Supports fire emergency broadcast mode so as to improve personnel evacuation efficiency in case of an emergency.

xxi. Supports broadcasting designated recorded voice audio at a designated time so as to allow for unattended broadcasting.

xxii. Capable of system extension through an Ethernet network.

cc. 600W HIGH EFFICIENCY POWER AMPLIFIER

The DA has the following main characteristics:

i. Energy-efficient CLASS-D power amplifier

ii. Contains 1/2/4 independent channels

iii. Each channel has 100V or 70V of output

iv. Supports balanced or unbalanced audio input

v. The DA is cooled through forced air-cooling

vi. Provide automatic re-settable over current, overload, overheating, overvoltage, under-voltage and DC protection

dd. CONFIGURABLE NETWORK PAGING CONSOLE

The Configurable Network Paging Console is hereinafter referred to as the “NPM”

The network paging microphone (NPM) connects to the system and related devices to transmit audio and control information through the Ethernet network. The NPM is used for paging, controlling broadcasts, monitoring zones, and for using the bidirectional intercom function.

The NPM has the following characteristics:

i. Lightweight and innovative patent outward design. Support embedded desktop installation

ii. 4.3-inch colour LCD touch screen. Can display system status and be operated for zones and groups’ division or global paging and broadcast control

iii. Simple and intuitive user interface

iv. Can connect with up to 20 units. Button numbers can be added via software configuration

v. Built-in monitor loudspeakers. Can utilize functions like zone monitoring and two-way intercom between stations.

vi. Digital audio processing to avoid acoustic fidelity distortion

vii. Can intercommunicate with other paging microphones and DCS in the network even when the connected DCS is not running

viii. 3 shortcut buttons: microphone talk mode switch, select all function and emergency broadcast

ix. Has one audio input and output port for playing BGM from a CD source or for recording an output.

ee. VOLUME CONTROLLERS

Volume Controllers have the following four types: 6W, 30W, 60W and 120W respectively. The features are as follows:

i. Build-in 24V DC forced cut-off relay;

ii. 5 volume levels control;

iii. Applicable to 3-wire, 4-wire and 6-wire systems;

iv. Standard 86X86 installation base-shell.

ff. LOUDSPEAKERS

Horn Loudspeaker - 15W Horn Loudspeaker with IP66 protection

C. Emergency Voice/ Alarm Communication

The EVAC system shall contain all equipment required for audio, communication, signalling and supervisory functions. This shall include speaker zone indication, digital voice units, and microphone.

Function: The EVAC system equipment shall perform following functions:

- Operate as a supervised dual channel emergency voice communication system.
- Operate as a two-way emergency communication system control centre.
- Supervise condition of every connection circuit.
- Audibly and visually annunciate any trouble condition of tone generators and digital voice units required for normal operation of the system.
- Provide all-call activities through activation of a single control switch. Provide selectable zone calling.
- Provide automatic, digitally recorded voice messages or field-programmed through the microphone.

The system shall be modular in construction and shall be capable of being field programmable without requiring the return of any components to the manufacturer. The system and associated equipment shall be protected against unusually high voltage surges or line transients.

a. GENERAL

A Public Address System shall be provided to inform / warn maintenance and service staff and give instructions to people in abnormal conditions during incident. Therefore, loudspeakers shall be installed every 60 m or as per drawing in the main tunnel tube. Operator terminals shall be in the Control Room Buildings at the portals or in the Control Centre.

b. SCOPE OF WORK

- Loudspeakers
- Amplifiers (wide-band amplifiers)
- Digital Sound Processing Unit
- E/O and O/E Converter
- Public Address Central Unit
- Cabling

c. TECHNICAL SPECIFICATION

The loudspeakers shall be fed by multi-range amplifiers, which shall be supplied with audio-data via electric loudspeaker cables from the Control Room Buildings and Niches. At the Control Room Building the central unit for the Public Address System shall be situated. This central unit shall be connected to the Control Centre by use of the tele control

system. The central unit shall be used as interface to the tele control system. The Contractor of E&M shall take the signals from there. At the Control Room Buildings / at the Control Centre, a control unit with a microphone for the announcements shall be situated. With these control units different circuits of loudspeakers can be switched on (e.g. all loudspeakers ON; only the loudspeakers near the accident ON; etc.) and the operator may control which way of voice communication via the loudspeaker shall be (if the operator speaks directly into the loudspeakers, or if predefined text conserves shall be played).

The loudspeakers itself shall work with supply-voltage (from the amplifiers).

With the loudspeaker arrangement of 60 m distance between each other as per final design compliance, to design system and best acoustic shall be provided. But nevertheless, it is very critical to operate a Public Address System in a tunnel. So, the Contractor has to guarantee a good understand ability and test the loud speaker system on a certain level of 'get the spoken words:

- even if no vehicle is in tunnel
- a vehicle runs into a tunnel (maybe 2 km away)
- a vehicle runs out of a tunnel
- a vehicle stands close/next to the passengers on the walkway

The dimension of the facility shall be determined in the way that one loudspeaker device, in a range of 1 to 4 kHz1 can reach a minimum sound pressure level of 110 dB(A) in a distance of 3 m / as approved.

d. LOUDSPEAKERS

Loudspeaker inclusive associated equipment as well as construction.

Technical Data:

Material: - Aluminium

Degree of protection: - IP 65

Nominal Power: - 15 W

Nominal Voltage: -100 V

Frequency range: - 200- 5000Hz

Sound pressure level: - min. 114 dB(A)

e. AMPLIFIER

The amplifiers shall be solid state amplifiers in cabinet of industrial design. The amplifiers shall be installed in the cabinets to provide good access to the control elements, control lamps, test and monitoring sockets and cables. The amplifiers shall be marked clearly readable and permanent at the front side.

CHARACTERISTICS

Remote control with inrush current limiting

Wear-free digital level control

Switch-On-noise suppression

Status signals for operation, standby, test

LED control display

TECHNICAL DATA

Construction type: Cabinet / by EPC Contractor / as approved

Inputs: 4xAudio-Lf-IN

Power: 4x 100 W

Distortion factor: 0 / less than 1 %

Frequency range: 60-15000 Hz

Output: 70V/SO Ohm- 100 V/100 Ohm, with overload and short circuit

protection Overheat protection

f. DIGITAL SOUND PROCESSING UNIT

The signal preparation shall be realized with a 24-bit AID-converter and the internal signal preparation with 32-bit floating-point signal processor, which can control each output channel, and as well as the total signals independently in gain and delay guides.

The digital sound processing unit shall be installed in the cabinets to provide good access to the control elements, control lamps, test and monitoring sockets and cables. The digital sound processing unit shall be marked clearly readable and permanent at the front side.

CHARACTERISTICS

Input with 1 x high-pass· and 1 x low-pass

Output with l x high-pass and 1 x low-pass

Status LEDs

Remote power on

Self-Monitoring

TECHNICAL DATA

Construction type:	Cabinet
AID-Converting:	minimum 16 bit
Sampling rate:	48 kHz
Inputs:	1 x Audio-LF-Input (XLR)
Input impedance:	10 k Ohm
Outputs:	4 x Audio-NF-Outputs (XLR)
Output impedance:	50 Ohm
Distortion factor:	less than or equal 0.01 %
Frequency range:	50 - 20000 Hz

g. E/O- O/E CONVERTER

The transmission of the low frequency signals from the loudspeaker central unit in the Control Room Building South to the optic fibre patch panels and further to the DSP units and amplifiers in the Niches and E & M niches shall be realized with Electrical/ Optical or Optical/ Electrical Converters.

TECHNICAL DATA E/O

Type:	Cabinet / as approved
Input LF:	LF signal
Output optical:	2x ST or SC for Multimode-optical fibre cable
Transmitted:	up to 2000 m
Power supply:	24VDC

TECHNICAL DATA O/E

Type:	Cabinet

Output optical: 2x ST or SC for Multimode-optical fibre cable

Output LF: LF signal

Power supply: 24VDC

h. PUBLIC ADDRESS CENTRAL UNIT

The Public Address Central Unit shall be installed with all necessary units (input modules, relay modules, control unit, etc.).

The necessary equipment shall be installed in the distribution cabinets to provide good access to the control elements, control lamps, test and monitoring sockets and cables. The equipment shall be marked clearly readable and permanent at the front side.

THE PUBLIC ADDRESS CENTRAL UNIT SHALL CONSIST OF FOLLOWING MODULES I EQUIPMENT

1x basis equipment with central control and operation unit

1x extension rack

1x digital voice recording unit

1x microphone I Line-In input module

1x communication terminal

1x relay module (blocking, error massages)

1x Line module (8x group lines, 1x connection to LAN)

INTERFACE TO TUNNEL RADIO SYSTEM

Low frequency range: 300 - 3400 Hz

Output level: 6 dBm ± 2 dB

Input level: between: 6 dBm and - 20 dBm

Impedance: 600 Ohm

Noise level: < - 46 dBm

Distortion factor: < 10 %

Furthermore, a voice recording system shall be linked with the Public Address System. There predefined text conserves shall be stored. The different text contents of those conserves shall be in accordance with the Client.

The text conserves (messages) shall be retrieved by the tele control system or even by the Tunnel

Radio System, so that it is possible to reach the voice messages even through the Tunnel Radio System.

i. DESKTOP STATION

The Desktop Station of the Tunnel Radio System also shall be used for the Public Address System.

j. LOUDSPEAKER CABLE

3 core 2.5 sqmm FRLS copper cable, as per Technical Data Sheet shall be used for connecting the loudspeakers. Depending on the used loudspeaker types by the customer, shall provide fitting system-cabling. The predefined values of the loudspeaker manufacturer shall be kept as per approved make.

k. OPTICAL FIBRE CABLE

The optical fibre cabling, which transfers the information from the Control Room Buildings to the EM-Niches shall be A-DF(ZN)2Y 12x12 E9/125 or as specified. This cable will be

installed by the Contractor of E&M.

The required fibres shall be used by the Contractor of Telecommunication for the Public Address System (plug-in system - E2000 / as specified and approved).

Table 13: TECHNICAL DATA SHEET FOR DIGITAL INTEGRATED SYSTEM MANAGER / CONTROLLER

Parameter	Value
Power Supply	
Main power supply	~100-240V, 50/60Hz
Backup power supply	DC 21.5V-28.5V
Main power fuse	T2AL 250V
Max. input power	120 W
Rated power	50 W
Audio Input	
Auxiliary input	0dB
Input impedance	20 kΩ
Frequency response	60Hz-16KHz
PTT microphone input	-51dB
SNR	>85dB
Audio Output	
Audio output channels	4个
Output signal	0dB
Record output	0dB
AVC Input	
Channels	4个
Input signal	-50dB/0dB, configured by switch
Input impedance	20KΩ
Phantom power	DC 24V, configured by switch
Frequency response	60Hz-16KHz
SNR	>65dB
Loudspeaker Circuit	
Output channels	8, with circuit fault detection function
Max. output load power	250W
Trigger Input / Output	
Trigger input ports	8
Trigger output ports	8 (NO, NC and COM)
Max. working voltage	AC 250V/DC 30V
Max. working current	2.5A
Others	
Monitoring loudspeaker	10W/8W
Ethernet speed	10M/100M
Ethernet interface number	4
Storage space	1GB
Work Condition	
Humidity	< 95%, without condensing
Working temperature	-10°C~+55°C
Storage temperature	-40°C~+70°C
Specification	
Dimension (W×H×D)	482 mm×88 mm ×420mm
Mount dimension (W×H×D)	580mm×235mm ×552mm
Net weight	9.3Kg
Gross Weight	12.5 Kg

TABLE 4:TECHNICAL DATASHEET FOR POWER AMPLIFIER

600W HIGH EFFICIENCY POWER AMPLIFIER	
Rated output power	Max. 600W
Main power supply voltage	AC 220V -15% - +10%50-60Hz
Backup power supply voltage	AC 220V -15% - +10%50-60Hz
Main power supply fuse	T10AL 250V
Loudspeaker output	100V / 70V
Frequency response	70-15KHz (+1dBto -3dB)
Input sensitivity and impedance	1.414VRMS& 20K ohm
Output voltage/impedance	100V/40ohms, 70V/19.6ohms
Signal-to-noise ratio (SNR)	>90dB
Nonlinear distortion	<0.1% (1KHz,1/3 rated output power)
Number of channels	2
Environment humidity	< 95%, without condensing
Working temperature	0 to +40°C
Storage temperature	-10°C to +55°C
Product dimensions (width × height × depth)	88mm × 440mm × 440mm

TABLE: 15TECHNICAL DATASHEET FOR PAGING CONSOLE

CONFIGURABLE NETWORK PAGING CONSOLE	
Power supply voltage	DC 24 V
AUX input	0 dB
AUX input impedance	10 KΩ
Frequency response	60 Hz – 16 KHz (local input signal)
Microphone input	-51 dB
Audio output	0 dB
Monitoring loudspeaker	2 W/8 Ω
Monitoring sound pressure level	Higher than 65 dB and lower than 115 dB (1 m in front of where the audio is being output)
Operating temperature	-10 °C to +55 °C
Storage temperature	-40 °C to +70 °C
Humidity	<95%, without condensation
VOLUME CONTROLLERS	
Rated power	6W/30W/60W/120W
Supply voltage	100V
Frequency response	50Hz~20KHz
Attenuation	5X2dB + off
Current consumption	20mA, 24V DC

TABLE 5: TECHNICAL DATASHEET FOR LOUDSPEAKERS

HORN LOUDSPEAKERS	
Max Power	25 W
Rated Power	15 W
Power taps @ 100 V	15 W / 7.5 W
Sound Pressure Level at 6W/1W (1kHz, 1m)	110.3 dB / 98.5 dB
Frequency range (-10 dB)	500 Hz – 5 kHz
Dispersion Angle (1kHz / -6dB)	140°
Protection	IP 66
Rated Input Voltage	100 V / 70 V
Rated Impedance	500 Ω / 1 kΩ

Connection	Cable
Dimensions (diameter x height)	225 x 165 x 240 mm
Weight	1.38 kg
Color	White (RAL 9010)
Case Material	ABS

LIST OF APPROVED / LIKELY SOURCES		
S. No.	**DESCRIPTION OF ITEMS**	**MANUFACTURER'S NAME**
Electrical System		
1	Diesel operated Power Generating Engine	Cummins India Caterpillar Koel Green (IEC) Sterling & Wilson Sudhir Power Jackson Kirloskar
2	Power Transformer Oil filled (33kV / 11kV)	ABB BHEL Schneider Siemens Crompton Greaves Alstom (Areva) Voltamp Tesla Transformers Ltd. Sudhir Power
3	Distribution Transformer Dry Type (11kV / 433V)	ABB BHEL Schneider Siemens Crompton Greaves Kirloskar Alstom(Areva) Voltamp Tesla Transformers Ltd. Sudhir Power Legrand
4	Synchronizing Panel, Auxiliary Panel and Motor Control Centre	Tricolite Electrical Industries Jackson Engineers Limited Adlec Control System Schneider Sudhir Power Legrand L&T
5	Power Distribution Panels and Distribution Boards	Schneider Siemens ABB Legrand Adlec L&T Tricolite
6	Automatic Transfer Switch	ASCO Cummins GE Power Control Socomec

LIST OF APPROVED / LIKELY SOURCES		
S. No.	**DESCRIPTION OF ITEMS**	**MANUFACTURER'S NAME**
Electrical System		
		L&T
7	Air Circuit Breaker (3/4 Pole), MCCB, MCB, Switch Fuse Unit, HRC Fuse, RCCB, Aux. Contactor, Changeover Switch	Schneider Larsen & Toubro Siemens ABB Legrand
8	Potential Transformer, Current Transformer	AE L&T Siemens Schneider Crompton Greaves Kappa Matrix Pragati
9	Instrument Transformer	Precise G&M Matrix Legrand Schneider AE Kappa Pragati
10	Numeric type Protection Relay, Generator Protection Relay, Automatic Power Factor Correction Relay	L&T Siemens Schneider ABB Alstom GE
11	Indicating Lamps LED Type, Push Buttons	L&T Siemens Schneider ABB Legrand Rishabh
12	Overload Relays with built in Single Phase preventer	Schneider Larsen & Toubro Siemens Alstom Legrand ABB
13	Capacitor Control Relay, Power Capacitor Panel	EPCOS Legrand Schneider ABB L&T Siemens Neptune
14	Electronic Digital Meters, Electro-Magnetic Meters	Trinity Conzerv system Pvt. Ltd. Automatic Electric ABB Siemens Schneider

LIST OF APPROVED / LIKELY SOURCES		
S. No.	**DESCRIPTION OF ITEMS**	**MANUFACTURER'S NAME**
Electrical System		
		HPL Socomec L&T
15	Static Power Meter and Logger	Conzerv System Pvt. Ltd. Ducatti Neptune L&T
16	33kV, 11kV XLPE copper conductor armoured Cables	Universal Cables Havells KEI Polycab RPG Finolex Gloster
17	433V XLPE insulated e-beam FRLSLH Cables	RR Kabel Universal Cables KEI Havells Finolex Polycab
18	33kV, 11kV Cables with Fire Protection Cover as per specifications	KBS Cable Eastern Copperfields Trading Inc. Legrand MEM Schneider Havells Finolex Polycab
19	LT Joining / Tremination Kit, Cable Glands double Compression, Cable lugs	Raychem Brass Copper & Alloy Ltd Dowell's 3M SV Systems Xicon Comet M-Seal HMI Trinity Touch
20	PVC insulated copper conductor stranded flexible wires	Finolex R.R.Kabel KEI Havells RPG Polycab Grandley Rallison CMI Delton
21	SS Conduit, PVC Conduits, Accessories for SS Conduit	BEC Polycab RMG Steels Pvt. Ltd. Vimco

LIST OF APPROVED / LIKELY SOURCES		
S. No.	**DESCRIPTION OF ITEMS**	**MANUFACTURER'S NAME**
Electrical System		
		Steelkraft JPC Flexicon Plica India Pvt. Ltd. Trinity Touch
22	Timer	L&T Siemens Schneider Minilec
23	Emergency Power Supply-UPS	Schneider Eaton Numeric Emerson Delta
24	Ni-Cd batteries	Exide Standard Hitachi Amaron Amara Raja AMCO Quanta HBL Statcon Panasonic
25	Battery Charger	Volstat Caldyne Amco Hitachi Exide Panasonic
26	Cable Trays, Cable Ladders	Rico Steel Cablofil Legrand Obo-Bettermann SV Systems MEM Schneider
27	Bus Duct	Schneider Electric Legrand Siemens L&T C&S
28	MS Pipes, GI Pipes	Tata Steel Jindal APL Apollo Jindal Star
29	MS Pipe / GI Pipe Fittings	Jainsons Industries Bharat Forge Pipeline Products Easyflex Unik Jindal Steel C-Brand

LIST OF APPROVED / LIKELY SOURCES		
S. No.	**DESCRIPTION OF ITEMS**	**MANUFACTURER'S NAME**
Electrical System		
30	33 kV / 11 kV Insulating Mats	DL Miller & Co. Ltd Premiere Polyfilm Ltd. RMG Polyvinyl India Ltd. Duratuff AM Vinyl Jyoti Electromat Padmini Trinity Touch
FIRE DETECTION & FIRE FIGHTING SYSTEM		
31	Fire Alarm System	Futech Multisystems Samay Project Services Firepro Vimal Fire Groups
32	Soft Fire Wall, Fire Barrier	Siemens Listec Cushion S90 Hilti 3M
33	Linear Heat Sensor, Smoke Detector, Fire Detection Unit, Control & Monitor Modules, Main Control Panel, Manual Call Stations	Siemens Listec LST Safeguard Edwards Techfab System AP Sensing Samay Project Services Honeywell Vimal Fire Group
34	Split A.C., Air supply unit, Ventilation Ducts, Control Panels for Room Ventilation	Blue Box Daikin Blue Star Voltas Hitachi Stulz LG Mitsubishi Toshiba Samsung
TUNNEL AUTOMATION & SCADA SYSTEM		
35	PLC and SCADA System, FO cables and accessories, Cabinets, Cat-6 Armoured FTP, Cat-6 Patch Cord, Fiber Terminations	ABB Schneider Siemens L&T Rockwell Panduit Pyrotech Siemens Honeywell Legrand Finolex

LIST OF APPROVED / LIKELY SOURCES		
S. No.	**DESCRIPTION OF ITEMS**	**MANUFACTURER'S NAME**
Electrical System		
		Lapp Polycab Molex Aksh Cisco TC communications Tyco
36	Lighting Sensors, Control & Automation	Schneider Helver Lutron Honeywell Bajaj Siemens
LIGHTING, PA, CCTV SYSTEM		
37	Video Management Software, CCTV Camera,	PELCO BOSCH AXIS Philips Siemens Schneider
38	Workstation and Monitor	HP DELL HCL Siemens Honeywell Schneider
39	Speaker, Radio system, Voice Alarm controller, Amplifier, IP phones	Bosch Ateis SystemSensor Motorola Zenitel Commend Schneider
40	High pressure Sodium Lamp, Fluorescent Lamps	Philips Osram Bajaj
41	LED Lighting Fixtures	Philips Wipro Osram Bajaj Thorn Surya Syska
42	Door contact, Plug Socket, Telephone Socket, Switches	EAZ Legrand Havels Crabtree Hensel Schneider L&T Spelsberg Cap electric BCH

LIST OF APPROVED / LIKELY SOURCES		
S. No.	**DESCRIPTION OF ITEMS**	**MANUFACTURER'S NAME**
Electrical System		
		Clipsal Panasonic Hager ABB
Miscellaneous		
43	Junction Box	Hensel Legrand
44	Potential Equalization Connections, Galvanized Steel & Copper, Galvanized Steel Ropes	Pipe Life Meinhart Obo-Bettermann SY Systems Erico Easyflex JMV Indelec
45	Earthing System	JMV LPS Ltd Erico Furse(ABB) Indelec Obo-Bettermann Macronite
46	Industrial Switches, Routers, Media Converters, Uplink Modules & Modems	Cisco Schneider Siemens TCCommunications Tyco D-link HP Alcatel Allied Telesis
47	Enclosure, Rack & Patch Panels, Containment	Netgear Schneider APC Korenix Globe Indiana Profab Engineer Rittal Valrack
48	Paints	AsianPaints Berger ICI ShalimarPaints Johnson & Nicolas Nerolac
49	Mannhole Covers and frames, CILA Fittings	Raj Iron Foundry Kartar Valves and Fittings Neco Electrosteel
50	Lightning Protection System	JMV LPS Ltd Furse Erico

LIST OF APPROVED / LIKELY SOURCES		
S. No.	**DESCRIPTION OF ITEMS**	**MANUFACTURER'S NAME**
Electrical System		
		Indelec OBO-Bettermann
51	Signages	Illumination Enterprise 3M Local & approved

Section 6

TUNNEL VENTILATION AND FIRE FIGHTING SYSTEMS

8.1. Tunnel Ventilation System

8.1.1. General Context

This section of the document describes the design, supply, manufacture, delivery, erection, operational maintenance, testing and commissioning of the Tunnel Ventilation Systems for the tunnels.

The purpose of the ventilation system is to ensure the safety of all persons who travel through the tunnel from harmful levels of vehicle emissions. Pollution measurement sensors will be installed throughout the tunnel, which will measure the intensity of gases present. The pollution level will determine when to activate the tunnel ventilation system to force out the harmful gases.

Tunnel ventilation systems should provide adequate in-tunnel air quality during normal and congested traffic operations and support the self-evacuation and rescue efforts during emergency incidents. Separately, the tunnel ventilation capacity requirements for emergency ventilation (typically for the control of smoke and hot gases during fire) must also be assessed and the system designed accordingly. Therefore, the ventilation system works for the following two modes:

- During normal operation of the tunnel
- During fire inside the tunnel.

The following general factors shall be considered during the ventilation system design:

1. Length of the tunnels (main tunnel and the entry and exit tunnels)
2. Cross section (width and height) of the tunnels.
3. Type of traffic
4. Fire safety

a. Presence of emergency exits

b. Change in the direction of fans

5. Cost and Environmental issues

a. Energy consumption

b. Localized and concentrated emission of polluted air from portals and stacks.

8.1.2. Tunnel ventilation during normal operation

The tunnel ventilation during normal operation should include estimation of pollutant load and estimation of fresh air requirement

1. <u>Estimation of pollutant load</u>

The estimation of total emission rate or pollutant load inside the underground tunnel shall be based on analysis of alignment to decide sections, and analysis of number of vehicles.

The following input parameters shall be considered for the estimation of pollutant load in terms of emission rates for each section of the tunnel:

a. Length of the tunnel/section

b. Road gradient or slope

c. Tunnel altitude

d. No. of different types of vehicles passing through the tunnel per hour. The vehicles mainly include, passenger car units (PCU), light commercial vehicle (LCV), heavy commercial vehicle (HCV), heavy goods vehicle (HGV), electric vehicles (EV)

e. Speed of the vehicles. The speed of the vehicles will be different for different traffic conditions, normal and congested ones.

f. Parameter influencing the power needed to propel the vehicle such as average mass of the HGV vehicle

g. Pollutant concentration in fresh air/ fresh air quality

2. Estimation of fresh air requirement

The fresh air requirement is based on the maintaining of admissible air quality. The air quality shall be measured in terms of concentration levels of gases CO, NOx and particulate matter (PM) deciding the visibility. Estimation of fresh air requirement should adhere to the requirement of threshold values associated with these elements.

a. Design values for CO:

The concentration of CO should not exceed 70 ppm during normal traffic and may permitted to have 100 ppm during congestion. Above 200 ppm, the tunnel operations shall be suspended

b. Design values for NOx:

NO by itself is not considered a harmful pollutant at commonly encountered levels. On the other hand, NO2 is noxious and can irritate the lungs and lower the resistance to respiratory infections such as influenza. A permissible average in-tunnel concentration of 1.0 ppm NO2 along the length of the tunnel at any one time shall be considered as the design value.

c. Design values for particulate matter (PM):

The presence of particulates leads to reduced visibility inside the tunnel. Therefore, visibility criteria are intended to support the ability of a driver to stop safely. The tunnel ventilation system must provide visibility levels that exceed the minimum vehicle stopping distance at the design speed.

The extinction coefficient K (1/m) expresses the tunnel visibility, the different visibility conditions considered for ventilation design are based on extinction coefficients 0.003 m^{-1}, 0.007 m^{-1}, 0.009 m^{-1} and 0.012 m^{-1} are slightly hazy, hazy, foggy and uncomfortable respectively.

For the present tender design, the maximum fresh air requirement for normal operation is 331 m^3/s.

Extent of Work

The work under tunnel ventilation system shall include the

• Axial and Jet Fans.

• Motorized Fire Dampers.

• Sound Attenuation.

• In- Tunnel and External Environmental Sensors and Monitoring Equipment. In addition, the extent of work shall include, but is not necessarily limited to:

• Interfacing with power supply systems, central monitoring & control system, fire services and

traffic control surveillance system.

• Preparation of technical calculations to demonstrate ventilation system performance to meet

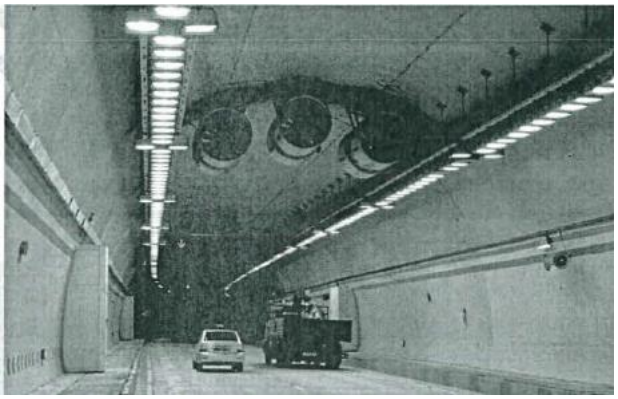
environmental criteria and fire scenario.

• Preparation of control specification for axial/jet fans based on traffic flow, traffic speed and

pollutant levels.

• Preparation of emergency operation procedures for tunnel ventilation system.

For each system, a complete commissioned, balanced and tested installation with Shop Drawings, As built drawings, Operation and Maintenance Manuals, Factory Acceptance Tests and Site Acceptance Tests shall be taken into account.



Jet Fans Installed in a Road Tunnel with Longitudinal Ventilation System

In addition to the main scope of work, the Contractor shall also allow for the following work:

• Provision of terminal Cubical for connection to the Power Supply System cabling.

• Provision of terminal cubicle for connection to the Central Monitoring and Control System; Traffic Control and Surveillance System; apd Fire Services System cabling.

• Allow for filling all holes left in floors and walls to Council and Authorities standards and

fire requirements.

Work By Other Trades

M&E Fire Systems Works

Provision of all fire detection and suppression systems associated with the tunnel.

M&E Electrical Systems Works

Provision of all Electrical Systems including HV & LV supply and distribution systems, and lighting systems.

Provision of Control Systems including Integrated Tunnel Controls Systems (ITCS), Plant Management and Control Systems (PMCS) and Traffic Management and Controls Systems (TMCS).

Underground Bulk Diesel Fuel Tank and associated Transfer Pumping System Works

Provision of Underground Bulk Diesel Fuel Tank and associated Transfer Pumping System, including backfilling.

HVAC Services Works

Provision of all Axial Fans, Dampers, Silencers, Ductwork and Controls system related to the North and South Portals and Mid-Vent shafts.

Tunnel Operational Vehicles

Provision of maintenance vehicles, emergency response-vehicles.

Design Criteria

To ensure that the ventilation system and its associated equipment meet the requirements of IRC SP-91-2019, PIARC and NFPA.

To ensure that the ventilation system can control the movement of smoke from a fire with a peak heat release rate of 50MW while an adverse pressure of 15Pa is acting on the exit portal.

To install an effective, versatile and energy efficient ventilation system that reduces· the time

and cost spent on maintenance.

To reduce the risk of incorrect operation of the ventilation system in an incident involving fire To ensure required air quality and visibility levels are maintained.

To provide adequate tunnel ventilation during tunnel maintenance closures.

Jet-fans located close to the fire has to be deactivated to compensate for the loss in momentum.

Pressurization axial jet fans shall be installed inside each cross passage at about mid-length.

The two types of ventilation systems used separately or in combination are as linear system and transverse system. In this case as both the tubes are unidirectional with ventilation shafts provided at either ends, linear system of ventilation shall be adopted.

It is proposed to reject all vehicles carrying flammable and dangerous goods on entire section of the tunnel during peak traffic times. This is to eliminate risk of such vehicle entering in to tunnels and getting involved in an accident. Such type of vehicles may cause fires of up to 1 OOMW having disastrous effect on tunnel structure. Based on present traffic volumes the HGV percentage is likely to be Jess than 5% of overall traffic volume. Hence a 50MW fire (BD 78/99 table 8.2) is adopted for design of ventilation to bring the impact to an acceptable level.

The tunnel ventilation sy.stem shall be designed to protect passengers upstream of the fire site and to provide a smoke clear evacuation path for passengers to escape and for rescue personnel to approach the fire site.

The maximum air velocity inside the tunnel due- to the ventilation system shall not exceed 10 m/s to permit passengers to safely walk in the tunnel during an emergency event.

The main tunnel ventilation equipmen~ is required to handle hot smoke during a fire emergency and shall be rated for 400 deg C for 2 hours.

The design life of all mechanical plant i,n this specification shall be 20 years.

The ventilation system in each bore can be controlled .. either automatically via the Integrated Tunnel Control System (ITCS) computer located in the Control buildings, or manually from the relevant Ventilation Control Panel in the LV Switch room.

Control of the fans is normally initiated automatically in response to increasing carbon Monoxide (CO), Oxides of Nitrogen (NOx) or poor visibility. Air Monitoring stations are located at the ends of the tunnel and mid points.

8.1.3. Tunnel ventilation during fire inside the tunnel

1. Tunnel ventilation during fire inside the tunnel shall include the choice of maximum heat load and design fire curve, selection of ventilation system, design and dimensioning of the system and design of firefighting systems.
2. The range of maximum heat release rate shall be considered as 1.5 - 300 MW, and the range of smoke release rate shall be 20 - 300 m^3/s. In addition to the requirement of supplying fresh air in the normal operating conditions the ventilation system should consider the following aspects to handle fires in tunnels:

a. The required tunnel air velocity during this scenario shall be more than the critical velocity required to avoid the back layering (flow of smoke upstream of the fire).

b. The heat release rate for the design shall be considered as 30 MW.

8.1.4. Tunnel air quality and visibility measurement system

1. The operational ventilation inside the tunnel shall be managed by monitoring the tunnel air quality. This shall be managed through the tunnel measurement system which consists of measurement of visibility affected by dusty environment, measurement of CO and NOx emissions, flow velocity and direction measurement and temperature measurement etc.
2. The visibility sensors shall comprise of transmitter (TX) and receiver (RX) which work on the principle of a single pass light transmission system also known as optical

measurement principle. The TX emits a visible (green) optical beam which is received by the RX. Any dust or smoke particles present will attenuate the light beam and cause the intensity of the light received by the RX to fall. This reduction in light intensity is used to determine visibility in the tunnel. The visibility criterion is mentioned in the normal operations above.

3. The tunnel air quality shall be monitored through the electrochemical cell technology to determine CO, NO & NO2 concentrations.
4. The ultrasonic airflow measurement technology shall be used in tunnels to measure the air flow velocity and direction. With no moving parts, the system requires minimal servicing and can be fully sealed from the tunnel's harsh environment. Measurements are independent of temperature, pressure and composition of the tunnel atmosphere. Other than a regular clean and check, it can be considered a 'fit and forget' solution. The two transducers shall be installed on the both walls of the tunnel in an angle of 45^0 to driving direction and shall work as sender and receiver alternately to determine the air flow speed and direction.
5. These sensors shall be positioned on the tunnel walls in equal distances to each other. The distance between air quality and visibility sensors shall be two times than the distance between the two air quality sensors and three times for air velocity and direction measurement sensors.
6. This system shall be connected to SCADA system through PLC and sensor measurements shall be provided through UPS.
7. Technical specification

a. The design materials shall be epoxy coated aluminium housing sealed to IP65

b. The measuring units shall be ppm for CO & NO, m-1 or m for visibility

c. The response time for CO shall be 2mins, for NO shall be 2 mins and for visibility shall be 10s to 2min. Device shall be rated for 20°C to +50°C temperatures.

8. The typical representative image and the corresponding drawing of the air quality and visibility measurement unit is shown below

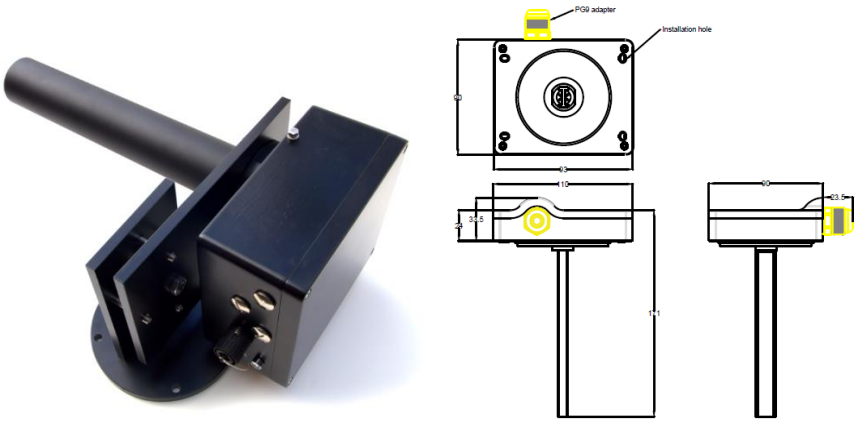


Figure 8.1: Air monitoring system

8.1.5. Ventilation system types

1. Fully transverse type Mechanical Ventilation system shall be provided inside the main tunnel tubes.
2. <u>Duct and damper dimensions</u>

a. The fresh and exhaust air ducts of sizes 12.5 m^2 each shall be installed above the tunnel vehicular area by constructing 25-30 cm thick concrete ceiling. These ducts shall be separated from each other. The ducts sizing both in main tunnel section and in cut and cover sections shall be adjusted based on the total volume available above the tunnel

vehicular area.

b. Appropriate jet fans shall be installed inside the duct above the vehicular tunnel areas and inside the shafts located at portals. The fresh air injection sizing shall be based on the fresh air supply. The fresh air openings of size 2.4 m^2 shall be provided for each 115 m distance. The extractor openings shall be provided with dampers. The maximum sizing shall be based on the fresh air and smoke flow rate, which shall be higher than the sizing of the fresh air openings. The typical extractor sizing shall be 60% more than the fresh air vent sizing (4 m^2). The opening through extractors shall be adjusted by operating the dampers according to normal and fire scenarios.

c. These fresh air vents and extractors shall be operated through actuators and shall remain open during normal operations. Actuators shall be operated automatically as soon as fire is detected, to adjust the vents openings and dampers in extractors.

d. During the fire scenarios, the fresh air vents in the distance of around 100 m from fire location shall be closed. The extractors in these regions shall be fully opened by adjusting the dampers, to remove the additional flow rate generated by smoke.

3. Fan technical specification

4. The design materials shall be selected to avoid galvanic and other corrosion of any jet fan fixings. A minimum material 304 or 316 stainless steel as per IS 6911: 1992 shall be used in tunnel. The jet fans shall be mounted with the suspension system, vibration sensor, anti-condensation heater, and dynamic balancing.

5. The traditional jet fans shall be made of carbon steel material (S-275 JR) having aluminium alloy blades for impellers. Also, the capacity shall be 90000 cmh and static pressure as 500 Pa. The fan area shall be 0.79 m^2 and power requirement shall be 30 kW.

6. Jet fan shall be reversible, and operating voltage shall be 415 V

7. The different parts of the jet fans, including construction and cabling (from fan to junction box) shall be designed to resist temperatures up to 250°C for 120 minutes. Fire test certificates provided by manufacturer shall be furnished to establish the withstand temperature and time parameters.

8. The detailed fan specification is given below:

Sr. no.	Description	unit	Specification
Jet fan			
1	Diameter of the fan	mm	1000
2	Overall length	mm	5000
3	Maximum distance from the ceiling	mm	1000
4	fan flow rate	cmh	90000
5	Installation factor		0.8
6	Maximum noise level	dBA	95
7	Jet fan type		Reversible with silencers
8	Blade material		Aluminum alloy
9	Shaft material		carbon steel material (S-275 JR)
10	Fan casting material		carbon steel material (S-275 JR)
11	Fan test arrangement		ISO13350
12	Thermal rating		F250
Fan motor			
1	Motor type		3 phase induction
2	Voltage	V	415
3	Normal running current	A	By bidder
4	Frequency converter		YES
5	Minimum motor efficiency	%	70

6	Shaft Power	kW	30
7	Thermal rating		F250
8	Protection class		IP65 and higher
9	Motor finish		Epoxy
Accessories			
1	Temperature elements for each bearing		PT100
2	Temperature elements for each winding		PT100

a. The typical representative image of the fan and its drawing is shown below.

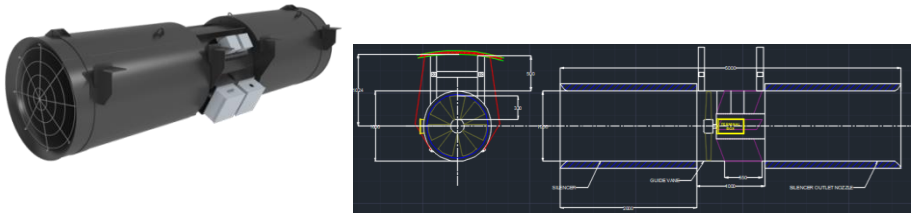


Figure 8.2: Jet fan

9. Fan positioning

a. A pair of jet fans shall be mounted inside both fresh and exhaust air ducts. The positioning of fans shall be decided based on the total air flow requirement, fan capacity and number of fans required for the same.

b. Traditional jet fans shall be positioned at every 115 m. The typical cross section of the tunnel indicating the duct sizing and fans positions shall follow the design given below.

c. Fans shall be positioned at same places during both normal and fire scenarios. Only the capacity of fans shall be altered based on the additional smoke flow rate. The smoke flow rate shall be designed corresponding to 30 MW fire rating 50 m^3/s.

d. The jet fans shall be installed in the main tunnel tubes as per drawings. The jet fans in the main tunnel shall not affect the safe operation of traffic. These fans shall not be affected by other tunnel installations. The lighting system of the main tunnel and other ceiling mounted installations shall not be affected by the operation of jet fans. The structural assembly of jet fans fixing arrangements on tunnel walls/ceilings shall be designed keeping in view the water lining of tunnel wall and shall be got approved, prior to taking up execution.

e. The complete construction, including safety restraints, shall be mounted and installed at the ceiling with stud bolts (tension and pressure). The different connections (specific dimensions of screws and bolts) of the jet fans including mounting frame etc. shall be adapted to the specific static and dynamic loads which occur in the tunnel (normal and emergency operation).

10. Power requirement and functioning of the ventilation system

a. Most of the power requirements in ventilation system belongs to the fan operations and associated equipment's such as dampers. Total estimated power requirement for operating each fan with 90000 cmh is 22.5 MW. Additional 30 % of power shall be considered for operating the fire safety equipment's. Total power requirement shall be 30 MW

b. The ventilation system monitored and controlled through the SCADA system. The jet fans shall be fully reversible and shall be operated at different speeds through PLC, which is connected to SCADA system, in accordance with the functional protocol. All the signals for forward start, reverse start and to stop to the jet fans shall be supplied through the PLC. SCADA system shall monitor the air quality and fire scenarios and accordingly the jet fans will be operated to provide the required flow rate. The PLC system shall provide the status of the fan such as the motor run status, its speed etc. The fans can be switched on as required from the PLC to adjust the system performance to the p-articular necessities, i.e.,

light traffic hours, peak hours, emergency, etc. with forward start, reverse start and stop functions.

c. All the necessary control equipment will be provided including all relays, transformers, manual switches, controllers, dampers, motors, wiring and all accessories necessary to perform the intended function of the system.

d. The Tunnel Ventilation system will be controlled and monitored by the Integrated Tunnel Control System having central computer system (CCS) for the same, which will be supplied and installed by others. The CSS shall receive data from the tunnel environmental sensors and traffic surveillance system to control the fans.

8.2. Firefighting equipment

According to the latest guidelines for Road Tunnels published by the Indian Roads Congress (IRC), the firefighting system of the tunnels shall be equipped with:

- Automatic fire detection systems
- Hand – Operated Fire Extinguishers
- Fire Hydrants
- Hose Coil with Supply
- Water Reservoir
- Sprinklers
- Fire pumps

8.2.1. Automatic fire detection system

a. Fire detection systems shall include detectors of heat (temperature and rate of rise), smoke, and flame. In addition, there shall be spot and linear heat detectors. LHD shall be used in the tunnel and spot detectors shall be used inside the duct too. Automatic fire detection systems shall be capable of identifying the location of the fire within 15 m (50 ft). Automatic fire detection systems shall be able to detect a tunnel fire incident of 5 MW or less within 90 seconds or better in a testing environment of 3 m/sec (590 fpm) air velocity. Fire alarms shall to be placed at every 100 m which are inline with other firefighting equipment, while the fire alarm sensor shall be at every 20 m as per section 7.4.6.6.4 of NFPA502. This shall meet the requirements of both the standards and permits some redundancies.

b. The LHD shall have the Fixed temperature set point or rate of rise temp setting with Programmable alarm. The operating temperature shall be in the range of -20 degree to 70 degree with alarms for open circuit and short circuit. The standard fixtures shall be duly approved by LPCB / EN54. The typical LHD representation is shown below.

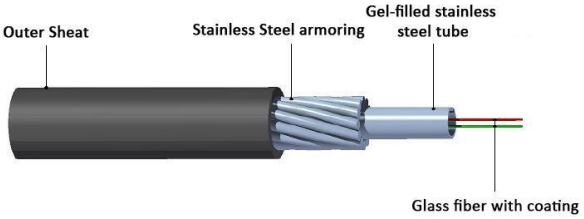


Figure 8.5: Linear heat detector

c. The fire alarm unit shall have EN54 approved fire alarm control panel, which shall be expandable, networkable, having option to interface to BMS with optional interface of LON Works, BAC net & MOD Bus, with a battery backup of 24hrs in normal condition and 30min in alarm condition. It shall have multi sensor with optical smoke element and thermal element. The fire detector shall have facility to mount in different comprehensive places as required and duly approved by LPCB / EN54. The typical fire alarm panel is shown below.

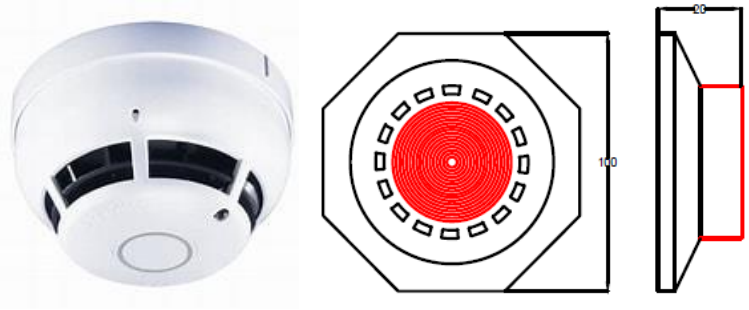


Figure 8.6: Fire alarm system

8.2.2. Hand – Operated Fire Extinguishers

The fire extinguishers shall have a minimum content of 6 kg. They shall be rated for liquid, grease and electrical equipment fires. These shall be installed at every 90 meters. The removal of it shall trigger an alarm to the SCADA system. Additional extinguishers shall be provided in the portals. The typical fire extinguisher is shown below.

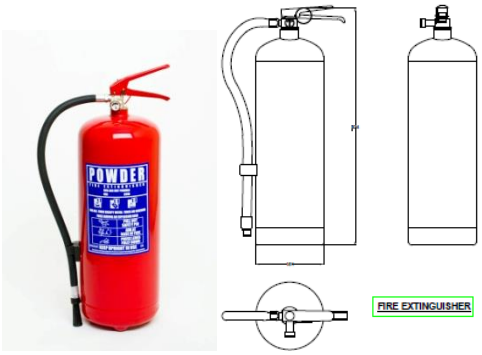


Figure 8.7: Fire extinguisher

Portable extinguishers shall:

- be rechargeable
- be hand operated
- comply with relevant standards
- be of approved manufacture
- be acceptable to the Fire Authority
- be of the type. and size as scheduled or as shown on the tender drawings Volume-Ill: Schedules.

8.2.3. Fire Hydrants

a. It is recommended that all road tunnels of sufficient length (200 to 1000 m according to the case) shall be provided with a water supply standpipe installed through the length of the tunnel. This standpipe shall have a minimum capacity of 1000 l/min at 0.5 MPa (PIARC, report 05.05.B, 1999, section 6.3.3.3). The standpipes are wet type. Hydrants should be placed at a spacing of 50 m. The fire main and hydrants shall be placed in such way that the walkway width remains clear of this. The connections between the main tube sections and entry/exit ramps are possible through the utility spacings. It can also be carried out using hose bridge on connectors. The utility spacing is also provided to connect the standpipes between cross-passage and main tunnel section. The appropriate sealing will be used to avoid the depressurization, and this shall be carried out by the Contractor during the detailed design place.

b. The typical output connection shall have sizing of 2 x 2 ½'' + 1 x 4'' and assembly depth shall be of size 550 mm. The fire hydrant shall be of type C (according to EN 14384 standard) with anti-icing system, helical spring closure. It shall have nominal pressure as 16 bar.

c. The typical fire hydrant is shown below.



Figure 8.8: Fire hydrant

8.2.4. Hose connections

These shall be placed at every 50 m along with fire hydrants and shall be made up of case aluminium alloy material. These shall have diameter of 100 m and designed for 23 kgf/cm^2 pressure. Typical hose pipes are shown below.

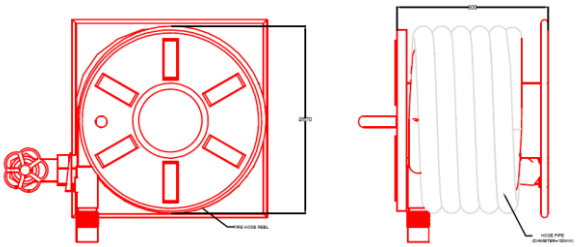


Figure 8.9: Hose pipes

8.2.5. Water reservoir

The total capacity of the water tank shall be sufficient to provide water supply for 60 minutes of operation. This shall have a minimum capacity of 60000 l. The tanks shall be placed closed to the pump room and shall be built at ventilation stations. The water level shall be monitored using SCADA system and in the event of drop in the level of it below the required one, it shall trigger an alarm.

8.2.6. Sprinkler system

a. The sprinkler systems shall have a type of fixed fire suppression system (FFS) that can be used in tunnels to help prevent fire spread and cool the tunnel structure. The sprinkler arrangement shall be used at every 4 m

b. The sprinkler system shall have bove ground pipes of type MS pipes "C" class with pressure rating as 11Kg/cm2 for 8 hours. The diameter of pipes shall be 200 mm, 100 mm, 32 mm, and 25 mm

c. The sprinkler bulbs shall be of 15mm diameter nominal bore quartzoid type. These shall have the temperature rating of 68 / 93 deg C of K-80 factor and shall have a pendant type of 93 deg C.

d. The typical system bulb is shown below.

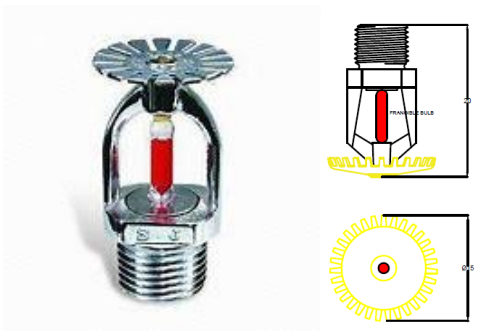


Figure 8.10: Sprinkler system bulb

Portable extinguishers shall:

• be rechargeable

• be hand operated

• comply with relevant standards

• be of approved manufacture

• be acceptable to the Fire Authority

• be of the type. and size as scheduled or as shown on the tender drawings Volume-Ill: Schedules .

8.2.7. Fire pumps

The three equipment shall be provided in the fire pump rooms, main pump, standby pump-diesel engine driven, and jockey pump. There specification is given as follows:

1) Electric Pump:

- Axial suction, radial impulsion
- Stainless steel shaft
- 4660 lt/min, head of 350 m rated 2900 rpm
- 2 poles three-phase asynchronous motor (415 V, 50 Hz)
- Protection: IP55
- Power: 150 kW
- Pressure range 3.5 kg/cm2 at the farthest sprinkler/hydrant point

2) Diesel Pump:

- Horizontal centrifugal end suction type
- 4660 lt/min, head of 350 m rated 2900 rpm
- CI casing, CI impeller.

The diesel engine shall be naturally aspirated (non-turbocharged) and electrically started. The engine shall have a speed governor to regulate the rated rpm within 5 % of its rated speed. The engine shall be complete with starting batteries full-wave selenium rectifier charger, isolator, leads, mounting frame etc. Engine rating shall be same as for the electric motor. Pumps and prime movers shall be truly aligned by suitable instruments. Entrepreneur shall provide necessary test certificates, performance curves of all the pumps. All the pumps shall be provided with approved type of Mechanical seals. On the suction and delivery lines, double flanged reinforced neoprene flexible connectors shall be provided.

3) Auxiliary Jockey Pump:

- Vertical Multi in line type fire pump
- 2900 RPM capable of delivering 460 lts/min against a head of 350 m.
- 415V, 3phase, 50Hz
- Bronze impeller
- Power: 1.5 kW
- Protection: IP55
- Shaft isolation with mechanical closure

The jockey pump shall start automatically on the detection of loss of line pressure. Upon

continuous pressure loss, the main fire pump shall start automatically and take over the pumping. The motor starters (direct on line or star-delta) shall consist of electrically actuated contactors. The starter shall be complete with ON-OFF push buttons, timers and auxiliary contacts and shall be fully automatic. There shall be an indicating lamp with each of the pumps and an ammeter and selector switch with the fire pumps. Fire pump starting shall be done through the MFACP. A remote start stop facility shall be provided in the Fire Control Room.

4) General considerations

The hydrant pumping systems shall maintain their respective delivery lines pressurized at all times for firefighting and wash-down. The impeller shall be statically and dynamically balanced after assembly into the shaft. The pumps shall comply in all respects to the requirements of the relevant standard. Each system comprises two equal size pumping unit, one duty and one standby. · Each station has been provided with a bypass valve for pump running test without interrupting the hydrant systems. The pumps shall have soft starters in order to minimise the impact of water hammer and to reduce the motor starting currents. The pump shall be sized to allow for a 1 0% upgrading of the maximum impeller size. Packing shall be coated with graphite grease before insertion. The shaft shall be fitted with renewable bronze wearing sleeves for the gland seal. Pumps shall incorporate drip wells and screwed outlets under the exposed ends of the glands. Copper drain pipework shall be run from each drip well to discharge over the nearest waste point.

Each pump and motor assembly shall be mounted on a common base of substantial mild steel or cast iron construction of adequate strength to maintain the components in correct alignment.

An identification plate of either brass or aluminium shall be screw fixed to the pump unit and shall include but not be limited to the following information:

- manufacturer
- model
- serial number
- size
- impeller rpm
- impeller size mm
- packing and spacers make/size/catalogue number ·
- pump rating# litres/sec.
- orifice plate details, if used.

If a hydrant point is opened, the jockey pump would start first because of the pressure drop. Since the demand of hydrant point cannot be catered by a jockey pump, the main pump would start. The control arrangement will be provided such that when main pump start, the jockey pump is cut off. In case the main pump fails to start, the standby pump set would come into operation

The typical pump arrangements is shown in the following figure.



Figure 8.10: Pumping station

8.3. Safe evacuation during emergency operation

a. The Cross passages shall be placed at every 500 m for the safe evacuation of the passengers in the emergency event. The pressurization of the escape routes shall be done such that the smoke does not enter these regions from the tunnel with fire (Typical value is 50 Pa and a velocity of about 2m/s)

b. To avoid fire spreading of fire inside cross passages the door frame, shall be designed to resist fire for at least a 1 or 2 hours of fire exposure. The double fire check door made up of steel (Grade St 32.0 of IS: 1977- 1962) material shall be installed in each cross-passage openings to both the tunnels. The door frame shall be at least 6 mm thick and shall be installed with hinge type support. The doors shall be of the size of 4.5 m X 4 m

c. The signage boards indicating the "FIRE EXTINGUISHER" shall be installed near the fire extinguishers (every 90 m) to indicate the same. The other signage boards such as "ASSEMBLY POINT" and "MANUAL CALL POINT" shall be appropriately placed between the cross-passages and at the emergency phone locations respectively. These boards shall be of the size of 150 mm X 150 mm, made up of luminescent safely, rigid green coloured sheet. These samples shall be approved by the Architect before procuring the same.

8.4. Codes and guidelines:

Following Indian and international codes and guidelines shall be considered for the ventilation system design and for fire-fighting equipment's specification:1

1. B SMILE, Request for Proposal for the "Consultancy services for preparation of DPR for the work of Construction of Underground Vehicular Tunnel from Hebbal Esteem mall junction to Silk Board KSRP junction", 2024.
2. IRC, Guidelines for Road Tunnels, IRC: SP-91-2019, 2019.
3. Maevski, I, Guidelines for Emergency Ventilation Smoke Control in Roadway Tunnels, NCHRP Research Report 836, 2017.
4. PIARC, Design Fire Characteristics for Road Tunnels, Report 2017R01EN, 2017.
5. PIARC, Fire and Smoke Control in Road Tunnels, Report 05.05.B, 1999.
6. PIARC, Road Tunnels: Vehicle Emissions and Air Demand for Ventilation, 2019R02EN, 2019.
7. PIARC, Vehicle Emissions, Air Demand, Environment, Longitudinal Ventilation, Report 05-02-B, 1995.
8. Directive 2004/54/EC: Minimum safety requirements for tunnels in the Trans-European Road Network

Section-7

ADVANCED TRAFFIC MANAGEMENT SYSTEMS (ATMS)

The following Specifications and Standards shall be applied in addition to 'Manual on Specifications and Standards for Tunnels' published as IRC: SP: 99-2013 with all amendments and additions till date.

1. Advanced Traffic Management Systems (ATMS)

1.1 General

The work would cover design, supply, installation, commissioning and/or operation and maintenance of Advance Traffic Management Systems (which is one of the components of Intelligent Transport Systems- ITS). The system would include out-door equipment including emergency call boxes, variable message sign systems, meteorological data system, close circuit TV camera (CCTV) system, traffic counting and classification system and transmission system. The indoor equipment would comprise a large display board, central computer (with Network Management System- NMS), CCTV monitor system, call center system or management of emergency call boxes housed in a control center with uninterrupted power supply. Any newtechnology, meeting the requirements specified in these specifications. should not be excluded. The systems shall meet the following objectives:

- Smooth and uninterrupted traffic flow
- Enhance road safety
- Real time information and guidance to users
- Emergency assistance round the clock
- Alerts for abnormal road and weather conditions
- Reduced journey time and inconvenience

1.2 System Requirement

ATMS shall provide the following facilities to Tunnel users:

- make emergency calls to Control Centre in case of accidents, breakdown, fire and ambulance.
- pre-warn the Tunnel users about unusual conditions on the road.

ATMS shall provide the following information/data to traffic managers for efficient and effective handling of traffic.

- information regarding location of any incident, incoming calls, help required and messages to be passed to third parties.
- Information regarding traffic congestion, speed and weather conditions.

ATMS shall provide the following controls to traffic managers:

- change the variable message signs from the Control Centre.
- mobilize the movement of ambulances, cranes & patrolling vehicles.

ATMS shall provide online recording and reviewing of the voice & visual information for record and analysis.

Value Added Systems in information dissemination to users of the Project may be taken up in future. These shall include the following:

(i) Value Added Systems in the form of real time information on traffic conditions, unusual events, congestion levels, weather conditions etc.; to facilitate project users as also the operator.

(ii) Through relevant websites including that for the Project SPV/Contractor

(iii) Subscription based alert systems

(iv) Dedicated TV channels pertaining to traffic movement

(v) Tie ups with FM radio channels or creation of dedicated AM radio channel

(vi) Dedicated Toll-Free Telephone Systems

Note: Local language is emphasized in *the above* systems.

The ATMS shall among many things comprise the following sub-systems:

i. Communication backbone

ii. Emergency Communication System

iii. Mobile Communication System

iv. Variable Message Sign System

v. Meteorological Data System

vi. Automatic traffic counter-cum-classifier system vii. Video Surveillance System

viii. Video Incident Detection System (VIDS)

ix. Central Control Room (CCR)

x. Weigh in motion for axle load measurement

xi. Power Supply System

These systems shall have outdoor equipment consisting of ECBs, VMS panels, weather sensors, traffic sensors, video camera etc. The outdoor equipment shall be connected to the control centre through a transmission system preferably comprising optical fibre cable, copper cable and interface equipment. There shall be one control centre per package and shall be located at any one of the toll plazas or administrative building and shall have monitoring equipment, online information acquisition equipment, processing equipment etc. It shall also have a graphic display board showing the highway and the locations of equipment and of incidents ....

1.3 Emergency Call System

Purpose and General Information

This is a communication medium to be installed on the tunnel and to be used by the users to make alarm call to the CCR in case of accidents & other problems in the tunnel.

Location

ECB shall be installed every 2km on either side of the road with one unit directly across the road from the other i.e. two call boxes every *2*km. It shall be placed along the left side of the carriageway for each direction of travel on the verge adjacent to the hard shoulders. At each location one ECB shall be master and the other slave. The master ECB shall be equipped with fibre optic interface, solar panel, battery. back-up and voice communication mechanism and shall also comply with all the requirements specified in this section for ECBS. The slave ECB shall be equipped at least with - activation button, vandal sensing mechanism, call progress indication LED, microphone, speakers - in a weatherproof housing. To discourage motorists who break down near the start or finish of the Tunnel from leaving it to obtain assistance, no telephones should be provided within the first and the last 300meters.

To achieve maximum visibility, care should be taken to avoid sitting on telephones near structures (e.g. bridge piers), particularly where these are close to the hard shoulder on the left-and bends.

Based on the above policy and the site condition, the location of the ECBs can be adjusted within 10% variation, however, only with the consent of the AUTHORITY. The optical fiber and splicing boxes shall be placed in the central median.

Major Components

Main components of the Emergency Call subsystem are:

1. Field components:

a. Emergency Call Box - Master and Slave. units

b. (Solar) power supply

c. Guard rail for protection

2. CCR components

a. ECB server

b. Headphone, speaker and microphone (Answering Unit)

c. Voice recorder/logger

d. Application software

e. Database software

Functional Specifications

1. The system shall be connected to the CCR over the OFC backbone.

2. ECB shall have a loudspeaker, microphone, solar panel,and battery and activation button with

LED indicating conversation. It shall be housed in vandal proof casing and operated in Tunnel

noise levels with built in diagnostic features.

3. The road user just needs to press the push button on the ECB and shall be connected to the CCR. In case the CCR operator is busy, the user shall hear a recorded message and shall hold till he/she is connected. The Master unit shall be connected to the CCR over the communication backbone. The Slave unit shall be connected to the CCR through the Master unit.

4. The CCR can also call any specific ECB for testing/calling in which case the ECB shall ring. The ring shall go off when someone presses the push button and connects to the CCR.

5. The ECB shall have the following features:

a. Vandal proof casing with tamper detection switch

b. Push button

c. Activation LED

d. Loudspeaker

e. Microphone

f. Two-way communication between ECB and CCR s. Solar panel with batteries

6. ECB shall have hands free operation.

7. Each ECB shall have use. instructions in Hindi, English, Marathi and Guajarati pasted or printed on it along with graphical instructions.

8. Reflective stickers facing the motorist shall be pasted on the ECB indicating that it is a phone.

9. The CCR software shall manage the calls to and from the ECB.

10. The ECB shall have a Ringing Tone to indicate progress of call when button is pressed; the Confidence Tone to indicate call is still connected when on hold and recorded message if line is busy.

11. There shall be up to four programmable auto dial numbers associated with the push button. The ECB shall automatically dial subsequent numbers if the first number is busy or unavailable.

12. The ECB shall automatically make an en9 call when the CCR telephone is disconnected.

13. All calls shall be recorded in the CCR voice logger/recorder along with date/time stamp. The voice recorder shall check for the following minimum fault conditions:

· Failure of recording electronics

· Failure of storage media used for recording

· Excessive recoverable errors on the storage medium

· Lack of activity on a channel

· Constant activity on a channel

· Constant ringing on channel (answered calls)

14. ECBs shall be programmable from the CCR and from the field by laptop.

15. The system shall have in-built diagnostics and shall be able to detect activation of tamper switch, mic/loudspeaker faulty, line faulty, low DC voltage online, cross talk and short circuit. Any diagnosed problem shall trigger an audio video alarm in the ECB server at CCR.

16. The diagnosed problems shall be stored in the system as events in the CCR. It should be possible to draw and print report of all such events on time and event category basis. ECB software at CCR shall allow recording and storing of maintenance and corrective action of each event when it is resolved.

17. ECB shall be powered by DC batteries which in turn shall be charged by solar panel. The battery shall support 7 days of operation (under normal circumstances) with minimum talk time of 90 minutes over 3 days in succession in case there is no sunlight for this period.

18. The ECB shall have tamper resistant screw bits on the outside and shall be security locked. It shall not be possible to open the ECB with normal tools or keys.

19. ECB foundation shall be concrete. Cables (communication/power) shall enter from the base of the ECB foundation.

20. Each ECB pillar shall be numbered.

21. The ECB mic/speaker shall be located 1-1.5m above ground.

22. The system shall not permit cancellation of any call before answering.

23. CCR Equipment

a. The CCR equipment shall consist of an ECB server with a large TFT display screen and voice logger for recording of all calls. It shall be possible to play back any call by the time specified. Playback should not interfere with record function. The screen shall show the map of the Tunnel with all Emergency telephones marked in accordance with their actual locations.

b. The GUI should be user friendly. ECBs shall be displayed in grey colour icons on the screen. When a call is initiated, the icon shall turn green and blink. When the call is in progress, the icon shall be green and stationary. On-hold calls shall be displayed in orange blinking. Faulty ECBs

shall be displayed in red, without blink.

c. The software shall have i.e., following features:

i. password protected & accessible only with relevant passwords

ii. data logging with the currently logged user/ operator details

iii. different levels of authorization for logging into the system

iv. automatic Call location identification

v. call disconnection by operator only

vi. operator call back facility

vii. automatic testing facility running in the background at operator selectable intervals *viii.* operator initiated ECB test facility

ix. facility for holding at least 10 calls from ECB's

x. Low battery and tamper alerts.

d. The following shall be recorded by the system software:

i. Time of incoming call

ii. Time of call answering

iii. Time of call termination

iv. Time of fault occurrence

v. Time of happening of events

e. It shall be possible to:

i. connect to any of the Calls on Hold

ii. hang up the call

iii. put on Hold the currently connected call

iv. Call back any of the ECB monitor faults and events

vi. Send e-mail to defined personnel intimating them about emergencies.

f. It shall be possible to draw the following l"(minimum reports for each ECB as well as all/selected ECBs:

i. Call count based on time period selection

ii. Average call duration

iii. Average waiting period for on-hold calls

iv. Unanswered calls (count)

v. Fault and diagnostics report

vi. Incident category-wise report

vii. The reports shall be tabular as well as graphical.

24. The following technical specifications are advised for ECBs. However the system integrator/operator can choose any other technology as long as other requirements are met.

a) Working : Work on VoiP

b) Communication: Ethernet type *over* optic fiber

c) Power: 12/24V DC, solar powered max 10W

d) Audio output : >95dB

e) Microphone : unidirectional, noise cancellation type

f) Wind speed resistance : 180kmph.

g) Mean Opinion Score : Min 4.0

25. ECB shall connect to the Outdoor Technical Cabinet Switch on optic fiber port/copper port (Ethernet may also be used, wherever feasible).

26. The ECB shall be vandal resistant in construction. It shall be made of stainless steel/ Aluminum alloy/ FRP.

27. ECB components shall be corrosion resistant; PCBs shall be coated to prevent water, moisture and fungus.

28. Each ECB shall be protected against external EMI, lighting and static by adequate shielding and earthing. The enclosure shall be provided with a grounding lug for connection to ground wire.

29. ECB enclosure shall be IP65 rated and shall be vermin and rodent proof. Doors shall be with labyrinthine seal, butyl-rubber gaskets, security locks, and metal hinges in conformity with UNE20324 standard.

30. The ECB shall operate in full duplex mode and use signaling which is inaudible to the user.

31. It shall be possible to adjust the acoustic properties.

1.4 Variable Message Signs (VMS)

Purpose and General Information Va riable Massage Signs (VMSs) are · to be installed for conveying the traffic conditions ahead to the drivers on rea l time basis as well as to display messages to support nationa l road safety campaigns. It may also include the variable traffic speed limit depending upon the requirements. Variable message signs (VMSs) shall provide traveler information for warning, regulating, routing, and managing the traffic in order to improve the overall traffic flow. The philosophy is to inform the driver of impending conditions-with up-todate information. The overall goal of VMS application is to provide permanently located signs that can be programmed remotely to communicate with the drivers the necessary information such that the driver can choose or be directed to the most appropriate route. The VMSs shall be controlled from the main CCR. Based on req uirement, the VMS may be fixed or portable in natu re. VMSs shall be used during the following cooditions:

Recurring Conditions

Mainly peak-period traffic congestion where demand exceeds capacity for relatively short periods of time.

· Non-recurring Conditions

Caused by random or unpredictable incidents. An "incident" is defined as any non-recurring event that causes a reduction of roadway capacity or an abnormal increase in demand. Such events include traffic crashes, disabled vehicles, spilled cargo, Tunnel maintenance and construction projects and adverse weather conditions.

VMS Usage Priorities

VMS should be used whenever pertinent messages wi ll assist motorists to make helpful decisions.

If, however, a situation arises, which requires the usage of a specific VMS for more than one ongoing condition, the following priority criteria should be used for displaying messages, in the order listed.

Safety

Any VMS message that is necessary to provide safety to the motoring public has the highest priority. Examples include failure of an Tunnel bridge, roadway or any major incident. In general, safety messages should be kept current and relate to a specific safety campaign. The period of time that a specific message is displayed for a safety campaign should be limited to a few weeks. Motorists tend to ignore messages that are displayed for long periods of time.

Roadway Closure

The VMS message shall include motorists regarding the roadway (particular carriageway, lanes of the Tunnel or crossroad) closure is important because such a closure directly affects the route a driver would take.

Minor Traffic Impact

A pre-warning message shall generally be used for planned full closures of carriageway of particular part of the Tunnel. The message shall be displayed no more than four days prior to the closure, and shall be immediately replaced with an appropriate message when the closure commences.

Pre-Warning

This category includes construction lane closures, blocking-incidents, and delay information.

Test

Test messages may be used to sign operation for testing the operating system and prior to placing a VMS into service.

Public Service Information

Public service information messages do not require the drivers to make any unexpected maneuvers with regard to upcoming traffic conditions. Some examples include "Buckle Up," "Speed Kills," and '~Don 't Drink and Drive." Various situations where VMS would be appropriate are as below:

· Incident signs as accidents, traffic diversions, incident management, monitor road work (men at work) adverse weather and. road conditions and operation with lane control signals; .

· Traveler information such as display of road construction activity in near future, messages for testing of the system and special events that effect the traffic flow;

· Public service announcements like messages related to driver safety campaign.

Location

VMS shall be provided as per locations determined later. A general policy adopted for locating VMSs is to provide VMS at an average interval of 1 Okm in each direction (not necessarily on the same gantry) to guide and forewarn the users about the traffic and weather conditions on the Tunnel. The most critical locations for insta lling permanent VMSs ·.are in advance of interchanges or Tunnels where drivers can have the opportunity to take some action in response to messages displayed on VMSs. A VMS should not compete with existing roadway signs.

Drivers generally do" not anticipate using a different route until they see and read a VMS message.

Drivers who are traveling in the inside lanes need ample time to read the message and change lanes to exit.

In general, a VMS should be permanently installed at the following locations:

4) The minimum distance of VMS on an Tunnel should be 1.5 km. prior to decision point. The signs should be visible from a distance of 300m.

5) There should be clear distance between existing road sign and VMS. The minimum distance between road signs and VMS should be at least 250m.

6) The average driver of motorized vehicle at high rate of speed can comprehend two messages panels. Each parcel should .be complete phrase and each phrase should be independent of the other. The messages shou ld consist of:

   A problem statement Road work/accident ahead

   An effect statement Delay/congestion

   An attention statement for certain group Motorist

   An action statement Take the next carriageway

7) Software - The VMS application software shall be installed in the CCR and shall have the

following features:

· GUI display

· Login/password protected access

· Database for storing messages and history

· Reports for- preconfigured messages, login time and user, date/time of display, fault history.

8) Maintenance walkway shall be. provided on the gantry at the rear of the signs . All component parts shall be easily and readily accessible by a single person for inspection and maintenance. There shall be room for a technician to work. The VMS should have in-built lighting to assist maintenance work during night.

9) Standards

VMS shall be designed to comply with the following protocols:

J 12966 parts 1 ,2 and 3

10) VMS shall be full matrix, true colour. It shall be made of modules and shall have equally spaced LEOs.

11) Text disp.lay- VMS shall be compliant to EN 12966. This includes. the following for LED panel:

· Beam : 83

· Colour : C1

· Luminance : L3

· Temperature : T3

· Resistance to pollution : 03

· For wind pressure on enclosure refer EN 12899

13) The LED Cluster shall consist of individual LED's encapsulated in a resonated plastic housing proving protection to the elements under worst climatic conditions.

14) The modules shall be individually addressable and field re placeable.

15) Failure of one LED module should not affect the output of any other.

16) The system ~esign shall be so as the display is legible from a distance of between 15m to 300 m in all weather and lighting conditions.

17} Elaborate Fault diagnostics shall be provided as per EN12966 or other equivalent international standards. Each pixel shall be monitored, and feedback shall be provided for the healthy status.

Minimum of the following shall be provided:

· Power Failure at VMS.

· Processor PCB Failure

· LED Cluster Failure

· Loss of incoming message *I* data not properly received.

· Temperature monitoring

18) The VMS shall withstand shock and vibration existing on the Tunnel.

19) Controller functionalities

· The controller unit shall provide brightness control facility. The intensity of the VMS shall have at at least six levels and it shall select the correct level automatically depending on ambient light conditions. For this, ·the VMS shall have photo sensor and dimmer control.

. The controller unit shall provide monitoring of ambient temperature of the housing.

· The controller shall be provided with a test port for local diagnostics via laptop.

20) The VMS software should permit the following:

· Broadcast messages

· Specific address messages

21) It shall be possible to perform fault diagnostics from the central control room via the software.

22) Maintenance panels shall be provided on the rear of the housing

23) Maintenance walkway shall be provided on the gantry at the rear of the sign-case. All component parts shall be easily and readily accessible by a single person for inspection and Maintenance. There shall be room for a technician to work. Access shall be made by entering the side of the housing. The housing shall be weather tight, and compliant to the NEMA 3R Standard.

The bottom panel of the housing shall have a minimum of four drain holes, with snap-in, drain filter plug inserts.

24) Ventilation - The ventilation system shall be forced into air. The system shall be designed to adequately cool the pixels from all sides along with the front and rear of the display module and all other internal components. The ventilation system shall have the following properties:

Positive pressure (exhaust fans are not acceptable).

The fans shall have ball or roller bearings, shall be permanently lubricated and shall require no periodic maintenance. The fans are to be positioned in· such a manner so as to provide a balanced air flow to the ventilation system in the event of failure of any fan.

a) Sign-case

All parts shall be made of corrosion resistant materials, such as plastic, stainless steel or alum inum. Painted steel is not acceptable. No se lf-tapping screws shall be used. The finish shall be matte black. The main body of the sign housing shall be constructed of aluminum with a natural mill finish. All exterior seams shall be continuously welded by an inert gas process, except for the coated fascia material. Tfie sig n-case shall be constructed of non-ferrous material to avoid rusting. The VMS sign-case shall have CFL lighting for maintenance during low light conditions. The performance of the sign, including the visibility and leg ibi lity of the display, shall not be impaired due to continuous vibration caused by wind, traffic or other factors. The angular alignment of the sign housing shall be adjustable in the vertical direction from (0 to10 degrees) down in one-degree increments to optimize the viewing angle. The housing shall be capable of withstanding the following conditions for the Vibration Test

1. Frequency range : 10- 50Hz
2. Vibration amplitude : 0.35mm·
3. Duration of endurance : 20 sweeps cycle
4. Duration at resonant frequency : 30 min+ 1 min

The Gantries for the VMS shall be designed, and the design shall be got approved from the AUTHORITY.

It includes all civil work like foundations etc. and shall be done as per relevant standards.

1.5 Automatic Traffic Counter-cum-Classifier (ATCC)

Purpose and General Information

This system shall be used for identifying and recording all types of vehicles on the Tunnel for effective··monitoring and data collection at the Control Centre. The· system shall be capable

of detecting and recording all types of vehicles plying on the Tunnel.

Besides the above vehicle classes, the system shall be capable of classifying any other vehicle category as per need. Vehicle classification should be user selectable based on vehicle parameters.

The system shall)1ave interface with the ATMS software for central monitoring.

Location

ATCC is proposed -to be installed at at suitable location. The final location may be adjusted as per the site condition, only with the consent of the AUTHORITY/Traffic and Transportation expert. The ATCC cabinet shall be installed in median or on the side of the Tunnel at a distance of 2 to 3 meters from the soft shoulder.

Major Components

Main components are:

a) Field components- consists of:

a. ATCC roadside cabinet *I* electronics/data logger

b. In-road/non-intrusive sensors and cables

c. Field computer/laptop

d. Power supply

e. Lightning protection and earthing

a. ATCC server

b. Application software

c. Database software

d. Report printer

Specifications

Volume-Ill: Schedules

· The ATCC should be designed for 8 lanes of traffic i.e. one cabinet/data logging unit should be able to record data for at least 8 lanes (4 in each direction)

· System shall use a combination of loop and piezo sensors or any other sensor mechanism (intrusive or non-intrusive) for correctly counting and classifying vehicles.

· Piezo sensor installation shall be in concrete. ASTM 1318-02 recommends a concrete pavement of 90m (60m before sensor and 30m after) to ensure good accuracy.

· The A TCC shall detect all classes of vehicles as per toll classification scheme.

· One or more of the following information shall be generated by the ATCC for each lane to correctly count and classify the vehicle:

a. Vehicle length ·

b. Vehicle speed

c. Number of axles

d. Axle spacing

e. Axle load (WIM) and GVW

f. Vehicle profile

g. Vehicle image

h. Any other proven technology with the consent of the Engineer and AUTHORITY

2. The ATCC shall provide the following additional information:

a. Occupancy

b. Headway

c. GaiJ

d. *Average* Speed

e. Flow rate

c) Data logger (roadside electronics): Th~ requisite number of entry and exit ports to communication systems shall be provided. The logic unit shall be micro-processor based. The systems be able to count and classify vehicles in each lane. There shall be an indication to display vehicle detection.

d) Data logger shall have a Tamper Detection Alarm facility. Any effort to tamper with the data logger shall trigger an audio and visual alarm in the CCR.

e) Data collection: The system shall be capable of sending data to the ATMS Software which shall enable the Software to count and classify the vehicles, and provide other required information Data collection shall be by RS232, RS4~2 or RS485 interface or IP connection.

f) Data Storage: The system should be able to upload data to the system as it occurs. The unit shall store data of at least two weeks in event of communication failure.

g) System Accuracy (95% confidence), whichever is applicable

a. Vehicle length(m): + 5%

b. Vehicle speed (kmph): + 1.5%

c. Vehicle count(nos.): + 1%,

d. Number of axles (nos.): +2%

: +2%,

h) Coincidence detection (lane straddling): The ATCC shall be capable of determining and recording vehicles that straddle adjacent lanes. This reduces double counting of vehicles on sites Where lane discipline is a problem.

i) Weather: The ATCC shall be capable of working with above mentioned accuracies, 24x7, in all weather conditions including heavy rain, dense fog and specified temperature range.

j) Reverse detection: The ATCC shall be capable of detecting and recording any vehicles traveling in reverse direction.

k) Data retrieval: The system shall be capable of data retrieval, direct data transfer through the Fiber Optic Network or locally through laptop.

I) Recording capability: The system shall have capability of recording vehicle counting and classification, speed, headway at set interval of 1-10 minutes.

m) Compatibility: The system shall have compatibility to transmit data over Optical Fiber Cable.

n) Fault monitoring: The system shall be capable of detecting and reporting the f0llowing fault events:

· Mains power failure

· Battery low voltage

· Modem communication error

· Laptop communication error

· CPU reset

· CPU failure

· Sensor fault (for each sensor)

· Door tamper

Software

The Application Software shall have the following features:

· It shall be GUI based

· The Opening Screen shall have password authentication

· Communications Parameters setting

· Configuration Parameters setting

· Raw and Binned data Retrieval

· Vehicle by vehicle Real Time Traffic Display

· Diagnostic Functions - Sensor Test

· Vehicle Classification Configuration & Weight Limits

Excavation and Earth Works

Excavation shall include careful removal of all materials or whatever nature and whether dry or wet, necessary for the construction of work, exactly in accordance with lines, levels, grades and curves shown on the plans

The bottom of the foundation shall be levelled both longitudinally and transversally or stepped as directed. Should any of the excavation be carried down to a level below the specified level.

The excavation shall be carried out in accordance with the dimensions shown in the sanctioned drawings.

Any obstacle encountered during excavation shall be reported immediately to the Engineer-in-charge and shall be dealt with as instructed by him. Removal of buried piping or cables shall not be done without prior permission of the Engineer-in-charge and the contractor shall take all measures to protect such lines. Cost of such protective measures and deemed to be included in the rates for various items of excavation. No blasting shall be permitted for excavation of foundation even in rocky formation without the prior permission of the Engineer-in-charge

The contractor shall provide suitable drainage arrangements, to prevent surface water from any source entering the foundation pits, at his own cost.

The contractor shall not undertake any concreting in foundation until the excavation pits is approved by the Engineer-in-charge.

If the soil is soft, loose or slushy the trench shall be widened for allowing berms on either sides or the sides sloped or shored up. During excavation if rocks or rocky soils are found, (if approved as suitable for foundation), those shall be leveled as far as possible and the small spaces which are difficult to level shall be filled in with Controlled Low Strength Material (CLSM).

Backfill Material.

Foundation trenches, column bases and the like shall be backfilled with selected excavated materials as described for imported fill, if approved by the Engineer.

Filling shall be done after the concrete or masonry in the foundation has fully set and its curing completed. It shall be done in such a manner as not to cause undue thrust on any part of the structure.

Back filling around completed foundations shall be done to the lines and levels shown on the drawings, including any trimming of the surfaces, as may be necessary. This will be done with selected and approved earth from excavation or otherwise with borrowed materials as directed by the Engineer-in-charge. Where sufficient suitable material is not available from the excavation, The Engineer-in-charge may direct to import suitable earth from different

sources. The refilling shall be done in horizontal layers of thickness not exceeding 15cms from pocket with careful watering, ramming and rolling etc., to obtain necessary level of compaction.

Imported Fill

Imported fill shall be selected, graded, hard, granular fill, free from clay and deleterious matter, with 100% free of stones larger than 75mm, upto 50% passing a 5mm mesh sieve and not more than 20% passing a 75micron sieve. It shall contain less than 0.2% total sulphates and less than 1.0gm per liter of water-soluble sulphates in a 2:1 water soil extract. Total soluble salts shall not exceed 2%

Section-8

Precautions in Tunnel construction near water body

1. General requirements

1. The Works involve cut-and-cover tunnelling near a lake, including piling, diaphragm walling, soil nailing, rock anchoring, excavation, dewatering, structural works and waterproofing, with associated environmental protection and monitoring.
2. The Contractor shall execute all activities so as to ensure:
3. Structural and geotechnical stability of the excavation, lake bund and adjacent structures.
4. No unacceptable deterioration of lake water quality, aquatic habitat, or groundwater regime.

2. Dewatering – execution, monitoring and reporting

1 Dewatering design and execution-

Dewatering discharge shall be routed through sedimentation and, where required, oil–water separators before disposal; uncontrolled discharge towards the lake is prohibited.

2.1.1 The Contractor shall submit a Dewatering Plan with: system layout, design drawdown, impact assessment on lake and surroundings, discharge points, erosion protection and contingencies.

1. Dewatering monitoring
1. At each dewatering discharge point:
2. At least one turbidity measurement per day on each day of discharge; more frequent if required by permits.
3. Visual checks for oil sheen, colour, odour and foam during daily inspections.
4. Groundwater: piezometers between excavation and lake shall be read at least once daily during active dewatering; frequency may be reduced subject to Engineer's approval.
2. Dewatering reporting
1. Daily dewatering log to include pumping duration, approximate flow, turbidity values, treatment status, discharge location, and observations on erosion or bank instability.
2. Weekly summary reports consolidating daily data, trend plots and any corrective actions where turbidity or drawdown approaches trigger values.

3. Waterproofing – execution, testing and documentation

1. System and workmanship
1. External waterproofing shall be a fully bonded membrane system (sheet or spray) with water stops, protection boards and drainage layer, designed for full hydrostatic head corresponding to design lake level.
2. Penetrations and construction joints shall be detailed to ensure a continuous watertight barrier; fixings through membrane shall only be as per approved details.
3. Testing and reporting
1. The Contractor shall carry out compartment/segment testing (e.g. vacuum or leak tests) prior to backfilling; defects shall be rectified and retested.
2. A Waterproofing Inspection and Test Plan (ITP) shall be submitted and updated, including hold points, test methods, acceptance criteria and records.

4. Slope support – soil nailing and rock anchoring

1. Soil nailing
1. Soil nails shall be designed for stability considering groundwater / lake effects and corrosion protection for the required design life.
2. Drilling spoil and flushing water shall be contained and treated; discharge towards the lake is prohibited.
3. Rock / soil anchoring
1. Ground anchors shall be designed, installed, grouted and tested (proof / performance tests) as per approved specification and schedule.
2. Grouting pressures near the lake shall be limited to avoid grout migration into lake-connected fractures; staged grouting shall be used where necessary.
4. Monitoring and reporting
2. Test records for all nails and anchors (lengths, capacities, test loads, extensions, failure modes) shall be submitted within 24 hours of each test series.

3. A register of all installed nails/anchors, with coordinates, levels, lengths, capacities, and protection systems, shall be maintained and submitted monthly and at completion.

5. Instrumentation and geotechnical monitoring

1. Instruments - As a minimum, provide and maintain:
1. Piezometers between excavation and lake, and upgradient if required.
2. Inclinometers near retaining systems and lake bund.
3. Settlement markers on ground and adjacent structures.

5.1.4 Strain gauges or load cells on critical anchors/struts, if specified.

5.2 Trigger levels and response

5.2.1 For each instrument type, green, amber–red control levels shall be defined in the design (e.g. 0.5, 0.8- and 1.0-times serviceability limit), with corresponding actions.

5.2.2 Amber exceedance: review of construction sequence and rate, temporary strengthening or reduced excavation/dewatering, increased monitoring frequency.

5.2.3 Red exceedance: immediate suspension of relevant works in affected zone, implementation of emergency measures, and review/approval of a revised method before resuming.

5.3 Monitoring frequency and reporting –

5.3.1Reading frequency (unless otherwise approved):

1. During active excavation/strutting near lake: daily readings for piezometers and settlement points; weekly for inclinometers (more frequent if trends are adverse).
2. During stable phases: frequency may be reduced as approved by Engineer.
2. Instrumentation reports shall include tables and graphs of readings vs time, trigger levels, interpretation of trends, and recommended actions, submitted weekly during active works.
6. Environmental monitoring and reporting (lake and surroundings)
1. Water quality and turbidity
2. Baseline monitoring of lake water quality (pH, turbidity, dissolved oxygen, TSS, oil & grease and other parameters as per PCB / EMP) prior to construction.
3. During construction, monitoring at agreed locations (upstream/control, near site, downstream):
2. Turbidity: at least daily during active earthworks/dewatering; more frequent if mandated.
3. Other parameters: at frequencies prescribed in EMP / consent conditions (e.g. fortnightly/monthly).
4. Environmental reporting
2. Monthly Environmental Monitoring Reports summarizing monitoring data, comparison with standards, non-conformances, incidents (spills, turbidity exceedances), corrective measures and training conducted.
3. Immediate incident reports within 24 hours for any pollution event (e.g. visible plume in lake, oil spill, major erosion), with description, cause analysis, containment and corrective actions.

7. Construction inspections, HSE and documentation

1. Routine inspections
2. Daily site inspections by Contractor for: excavation stability, condition of support, slurry and spoil containment, silt fences/turbidity curtains, dewatering systems, access, and housekeeping near lake.
3. Findings shall be recorded on a standard checklist and made available to the Engineer on request.

7.2 Reporting and record keeping

The Contractor shall maintain and submit:

7.2.1 Daily Site Diaries including key activities, labour, plant, weather, HSE observations and any environmental non-compliance.

7.2.2 Weekly Summary Reports combining dewatering, instrumentation and environmental data with interpretation.

7.2.3 Quarterly consolidated reports as required under statutory clearances, in formats compatible with State / Central authorities.

8. Non-compliance, penalties and work stoppage

1. Exceedance of defined structural or environmental limits without adequate and timely corrective action shall constitute non-compliance and may trigger:
2. Direction to increase monitoring or modify methods.
3. Suspension of specific activities until satisfactory mitigation is implemented.

4. Contractual penalties or cost recovery for damage to lake environment or third-party assets, as per Contract.
5. Repeated serious non-compliance may result in termination of the relevant work section in accordance with the Contract.

Section-9

CIVIL & STRUCTURE

Excavation and Earth Works

Excavation shall include careful removal of all materials or whatever nature and whether dry or wet, necessary for the construction of work, exactly in accordance with lines, levels, grades and curves shown on the plans

The bottom of the foundation shall be levelled both longitudinally and transversally or stepped as directed. Should any of the excavation be carried down to a level below the specified level.

The excavation shall be carried out in accordance with the dimensions shown in the sanctioned drawings.

Any obstacle encountered during excavation shall be reported immediately to the Engineer-in-charge and shall be dealt with as instructed by him. Removal of buried piping or cables shall not be done without prior permission of the Engineer-in-charge and the contractor shall take all measures to protect such lines. Cost of such protective measures and deemed to be included in the rates for various items of excavation. No blasting shall be permitted for excavation of foundation even in rocky formation without the prior permission of the Engineer-in-charge

The contractor shall provide suitable drainage arrangements, to prevent surface water from any source entering the foundation pits, at his own cost.

The contractor shall not undertake any concreting in foundation until the excavation pits is approved by the Engineer-in-charge.

If the soil is soft, loose or slushy the trench shall be widened for allowing berms on either sides or the sides sloped or shored up. During excavation if rocks or rocky soils are found, (if approved as suitable for foundation), those shall be leveled as far as possible and the small spaces which are difficult to level shall be filled in with Controlled Low Strength Material (CLSM).

Backfill Material.

Foundation trenches, column bases and the like shall be backfilled with selected excavated materials as described for imported fill, if approved by the Engineer.

Filling shall be done after the concrete or masonry in the foundation has fully set and its curing completed. It shall be done in such a manner as not to cause undue thrust on any part of the structure.

Back filling around completed foundations shall be done to the lines and levels shown on the drawings, including any trimming of the surfaces, as may be necessary. This will be done with selected and approved earth from excavation or otherwise with borrowed materials as directed by the Engineer-in-charge. Where sufficient suitable material is not available from the excavation, The Engineer-in-charge may direct to import suitable earth from different sources. The refilling shall be done in horizontal layers of thickness not exceeding 15cms from pocket with careful watering, ramming and rolling etc., to obtain necessary level of compaction.

Imported Fill

Imported fill shall be selected, graded, hard, granular fill, free from clay and deleterious matter, with 100% free of stones larger than 75mm, upto 50% passing a 5mm mesh sieve and not more than 20% passing a 75micron sieve. It shall contain less than 0.2% total sulphates and less than 1.0gm per liter of water-soluble sulphates in a 2:1 water soil extract. Total soluble salts shall not exceed 2%

Anti Termite Treatment

Area should be cleaned before application and the treatment should be done as per the contractual specifications/ IS code. Saturation of the soil with the chemical emulsion to be ensured.

Treatment along outside of foundations: The soil in contact with the external wall of the building shall be treated with chemical emulsion at the rate of 7.5 l/m2 of vertical surface of the sub-structure to a depth of 300 mm. To facilitate this treatment, a shallow channel shall be excavated along and close to the wall face. The chemical emulsion shall be directed towards the wall at 1.75 l/m of the

channel. Roding with 12 mm diameter mild steel rods at 150 mm apart shall be done in the channel. If necessary, for uniform dispersal of the chemical to 300 mm depth from the ground level. The balance chemical of 0.5 l/m shall then be used to treat the backfill earth as it is returned to the channel directing the spray towards the wall surface.

RCC/PCC works

Cement

The cement material used shall comply with relevant codes as specified in IS 456-2000. Bags of cement shall be stored in a waterproof store with a raised floor. The cement shall be used in the order in which it arrives at site. Additives shall not be permitted without the consent of the Engineer. Samples of cement to be used in the works shall be approved by the engineer and samples shall be provided for approval before delivery of materials to site.

Aggregate

Aggregates used in the construction shall comply with the requirements of IS 383:2016, "Coarse and Fine Aggregates for Concrete – Specification

Coarse Aggregate

As far as possible, preference shall be given to natural aggregates, such as crushed stone, gravel, and sand, which meet the requirements of IS 383.

Recycled aggregates shall be used in accordance with the guidelines and norms specified by:

- Green Rating for Integrated Habitat Assessment (GRIHA)
- Indian Green Building Council (IGBC)

The use of recycled aggregates shall be subject to the approval of the Engineer and shall meet the requirements of IS 383. The nominal size of the graded aggregate shall be 20 mm to 5 mm or as specified.

Fine Aggregate

As far as possible, preference shall be given to natural fine aggregates, such as river sand, quarry dust, or other naturally occurring materials that meet the requirements of IS 383.

Aggregates shall be stored on clean, self-drained concreted or paved areas with adequate division walls to prevent contact between different grades or types of aggregate. Graded aggregates, which have segregated in stockpiles, must be thoroughly mixed before use.

Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils. acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water/RO water is generally considered satisfactory for mixing and curing concrete

Admixtures

Admixture. if used shall comply with the requirements of IS 9103:1999, "Specifications for Concrete Admixtures

The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures

Approval: The use of admixtures shall be subject to the approval of the Engineer, based on the results of the trial mixes.

Quality Requirements: Admixtures shall meet the following quality requirements:

- Chemical Composition: The chemical composition of the admixture shall be as specified in IS 9103.
- Physical Properties: The physical properties of the admixture, such as density and viscosity,

shall be as specified in IS 9103.

Reinforcement

The reinforcement shall be of Mild steel and medium steel wire, conforming to I.S. 432-1960 or TMT bars conforming to I.S. 1786-2008 or deformed steel bars conforming to I.S.1139 with up-to-date modification.

Epoxy coated reinforcement where specified shall be fusion bonded conforming to ASTM A775.

Bars shall be bent cold by machine or other approved means. Reinforcement shall be accurately positioned and rigidly supported and tied with binding wire to prevent displacement during the concreting.

Bar bending schedules shall be prepared by the Contractor in accordance with the drawings and BS 4466 at least fourteen days in advance of any bending of reinforcement, and they shall be approved by the Engineer before any bars are cut or bent. Bars once bent shall not be straightened or rebent. Heating or welding of the reinforcement will not permitted unless the prior consent of the Engineer has been obtained in writing.

Reinforcement shall not be stored in contact with the ground.

Mixes and Mixing of Concrete

Unless otherwise specified concrete in various locations shall be as follows:

Usage	Concrete Class	Min. Cement Content	Max. W/C Ratio
Reinforced cement concrete in all locations	20N/mm2	330	0.5
Plain cement concrete in floors and pacing and other situations not covered under above	20N/mm2	330	0.5
Binding Concrete	1:3:6	220	0.55
Plain cement concrete 1:2:4 for underground piping benching and similar	1:2:4	330	0.55

Where the concrete is specified to give strength more than mentioned above, the concrete shall be designed and tested according to IS 516 or to other approved standard to the full satisfaction of the Engineer.

The slump test shall be used as a guide to the workability of the mixed concrete, which shall be carried out by using a slump cone in accordance with IS 1199: 1959 "Methods of Sampling and Testing of Concrete"

The Engineer's approval to the Contractor's proposals for concrete proportions in no way relieves the Contractor of his responsibility for providing concrete of the minimum strength required.

Concrete shall be mixed in an approved Ready Mix Concreting (RMC) Batching Plant. The Volume of Mix shall be as per approved Mis Design Report.

The provisions of IS 4926 will govern the supply and use of ready mixed concrete.

Sampling and Strength of Designed Concrete Mix

Samples from fresh concrete shall be taken as per IS 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS 516

Adequate number of cube moulds along with slump cone shall be placed at work site. The samples shall be taken in accordance with relevant BIS/ technical specifications. As per clause 15.2.2 of IS:456, the frequency of sampling shall be as follows:

Quantity of Concrete (cum)	No. of samples
1-5	1

6-15	2
16-30	3
31-50	4
50 & above	4+1 additional sample for each additional 50 cum or part thereof

Freshly laid concrete shall be protected from rain. After about two hours of laying, when concrete has begun, to harden, it shall be kept damp by covering with wet gunny bags for 24 hours and7 days continuously. If specified curing may be done by covering concrete with special type of waterproof paper so as to prevent water escaping or evaporating.

SLUMP TEST

The Contractor shall keep at the site of the works for the constant use of the Consultant's representative a standard slump test mold and shall provide facilities throughout the construction for tests to be made as and when the Client may require. The slump cannot be definitely stated until tests have been made using the materials adopted for the work, but it is anticipated, that the slump of between 25mm to 50mm will be required.

The Contractor at his own expense shall establish a field laboratory to carry out all preliminary tests, work tests and also to work out grading and proportioning of aggregates in order to obtain and maintain uniform quality of work. A 150 mm cube testing machine shall be installed by the contractor at his own expense to ascertain the strength of concrete from time to time. The contractor shall supply all materials, labour and testing machines for preparing and testing sample as required by the Engineer. The concrete shall also be got tested in an independent laboratory approved by the Engineer at the discretion of the Engineer or his authorized representative at no extra cost.

TRANSPORTING PLACING AND COMPACTION OF CONCRETE

The concrete shall be transported maintaining required workability in a manner such as to avoid the segregation of the constituent materials, and loss of any of the ingredients. It shall be deposited as nearly as practicable in its final position to avoid re-handling. It shall be placed and compacted before setting commences and should not be subsequently disturbed. Methods of pouring should be such as to preclude segregation, and to avoid displacement of reinforcement and movement of formwork.

The concrete should be thoroughly compacted and fully worked around the reinforcement, around embedded fixtures and into the corner of the formwork without formation of honey combing, pinholes or surface irregularities and any other defects whatsoever. The use of mechanical vibrators having capacity of producing vibrations at a rate not less than 5000 cycles per minute is recommended. Over vibration or vibration of very wet concrete is harmful and should be avoided; under vibration is also harmful. In addition to mechanical vibration, sufficient hand tools must be used to ensure full consolidation around reinforcement and at edges and corners.

The deposition of concrete shall be carried out as continuously as possible to reduce to a minimum joint between new concrete which has set. Where construction joints are necessary, they shall be formed at right angles to the axis of the member concerned by the insertion of rigid stopping off form, against which concrete can be properly rammed. Concrete shall not be dropped from a height of more than 1.0 M. No unset concrete shall be brought into contact with unset concrete containing cement of different type. Special permission and instructions shall be obtained when concrete has to be deposited under water. Under water concreting shall be done with the help of tremi pipe line only. Concrete shall contain 10% more cement than that required for the specific mix placed in dry condition.

Accumulation of set concrete on the reinforcement shall be avoided. Before fresh concrete is deposited upon or against any concrete which has already hardened, the surface of hardened concrete shall be well roughened, if necessary, by chipping and all Latinate removed. The surface shall then be swept clean with wire brushes, thoroughly wetted and covered with a thin layer of cement mortar.

Care should be taken such that there are no cold joints while laying concrete.

Use of Vibrators:

a. Immersion vibrator shall be inserted vertically at points not more that 450mm apart and withdrawn when air bubble seizes to come to the surface. Immersion vibrator shall be withdrawn slowly.

b. The immersion vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

c. The use of surface vibrators will not be permitted under normal conditions. However, for thin slabs, such as highways, runways and similar constructions, surface vibration by specially designed vibrators may be permitted upon approval of engineer.

Shuttering/ Formwork for Concreting

Formwork, centering, and shuttering should be constructed with materials that effectively prevent grout leakage and absorption of water from the concrete. It is recommended to use mild steel (MS) sheets as required, adhering fully to the standard specifications outlined in IS 1200 Part V. These measures shall be undertaken prior to laying the concrete to ensure confinement, support, and the maintenance of the concrete's position.

The design of formwork shall be per IS 14687:1999 "Formwork for Concrete - Code of Practice"

The following upward cambers are suggested to the formwork

i. Cantilevered slabs - 3 mm to every 1.5m of span

ii. Cantilevered beams - 6 mm to every 1.5m of span

iii. Slabs over 3m span - 3 mm to every 3.0m of span

iv) Beams over 6m span - 6 mm to every 3.0m of span but not exceeding 40mm.

Removal of formwork

The removal of formwork is governed by IS 456:2000, which specifies the guidelines for the removal of formwork for different types of concrete elements

The formwork shall be removed avoiding shock or vibration that may cause any damage to concrete.

Formwork shall be removed only when concrete reaches the strength to withstand various loads while striking as per above IS codes.

Type of Formwork	**Stripping time**
Vertical formwork to walls, columns, beams	16-24 hours
Soffit formwork to slab (props to be re-fixed immediately after removal of forms	3 days
Soffit formwork to beams (props to be re-fixed immediately after removal of forms)	7 days

Expansion Joints

Expansion joints to be provided as per guidelines and according to IS 3414. Unless otherwise specified, the expansion joint filler shall be a 20mm thick bituminous board, subject to approval.

Sealant : The expansion joint shall be pointed with a 2-part polysulphide sealant, conforming relevant IS , to a minimum depth of 20mm.

Wall Ties

Unless otherwise specified wall ties shall be zinc coated, 3mm mild steel fish tail type, 300mm long to comply with the requirements of IS 4326:.

Vapour Barrier

Vapour barriers shall be polythene and shall consist of 1000 micron approved hydro-carbon

thermoplastic resin or equivalent obtained from an approved manufacturer.

Internal Civil Finishing Works

Brickwork

The following I.S. apply to this section:

I.S. NO.	SUBJECT
1077-1992 (R2002)	Common burnt clay building bricks
IS: 1200 (Part-III) – 1976	Methods of measurement of Brick works
IS: 2212 – 1991	Code of practice for brick work
IS: 3495 (Part I to IV) 1992 (R2002)	Methods of tests on burnt clay building bricks

Classification of bricks and dimensions

Bricks shall be classified on the basis of their minimum compressive strength as given below :

Class Designation	Average compressive strength	
	Not less than (N/mm2)	Less than (N/mm2)
12.5	12.5	15
10	10	12.5
7.5	7.5	10
5	5	7.5
3.5	3.5	5

The brick may be modular or non-modular.

Type of Bricks	Nominal Size mm	Actual Size mm
Modular	200 x 100 x100	190 x 90 x90
Non Modular	230 x 115 x75	225 x 110 x 70

The selection of bricks shall be done as per the requirement and specifications of the work. The quality of clay bricks, Fly ash bricks & Solid concrete blocks & other masonry units shall be as per relevant IS standards bricks shall be soaked well in water for at least 1 hour prior to use and will be in surface dry condition at the time of lying.

Cement mortar as specified, shall be made with fine natural sand and specified Portland cement.

Block Masonry

Precast concrete blocks shall comply with the requirements of IS 2185 (Part 1 to Part 3):2005. The materials used for the manufacture of blocks (i.e. cement, aggregates and water) shall comply with the relevant clauses as specified in “Concrete Masonry Units - Specification”.

Precast concrete blocks shall be made in approved block making machines in the thickness required. The materials for all blocks shall be mixed upon a clean mixing platform or in an approved mechanical mixer and shall be gauged with sufficient water to enable the materials to bind together under pressure and thereafter placed in the block making machine in layers not exceeding 75mm, each layer being thoroughly tamped or, if approved, machine vibrated.

Types of blocks to be used are as follows:

Minimum Compressive Strength – as per IS: 2185 (Part I & II)

Size of Block(mm)

Length : 400, 500 or 600 mm

Height : 200 or 100 mm

Width : 50,75, 100, 150,200, 2500r300 mm

- Non-Load Bearing Walls : Not less than 3.5 N/mm2
- Load Bearing Walls : Not less than 7.0 N/mm2

Blocks may solid or hollow for load bearing walls but they must be solid below plinth level.Blocks Made from natural and recycled materials like Cement, lime, sand, water, lime, Gypsum and an expansion agent like aluminum powder CAN BE USED in accordance with the guidelines and norms specified by:

- Green Rating for Integrated Habitat Assessment (GRIHA)
- Indian Green Building Council (IGBC)

Testing of Blocks

Testing of blocks shall be in accordance with IS: 2185: Part I

Mortar

Cement and water for mortar shall be as specified for "concrete work"

Sand for mortar to be natural sand, crushed stone, or crushed wadi gravel conforming to the requirements of IS 383:2016.

Plastering

The thickness of plastering shall be minimum 12 mm (1/2") with appropriate rendering as per IS 2402- 1963.

Flooring, Dadoing and Skirting Works

Flooring with ceramic and vitrified tiles

The tiles shall be of approved quality, shape, size, color and free from any deformities, and shall comply to IS 13630 (Part 1 to Part 4):2014

The tiles shall be tested for its mechanical properties such as strength and hardness prior to usage and stacked in an enclosed space properly as per manufacturer's instructions.

Granite/ marble works

The tiles shall be of approved quality, shape, size, color and free from any deformities, and shall comply to IS 3316:1974

- The marble/granite stone should satisfy the following requirements:
- The stone should be hard, even, sound and durable.
- The slabs should be of uniform color, free from stains, cracks, decay and weathering.
- The slabs shall be sawn or cut in plane parallel to the natural bed of the slope.
- They shall be cut in perfect line; and right angles should be maintained.
- They shall be uniform in size and the edges shall be truly square.

IPS Flooring

The Concrete Flooring shall be carried out in accordance with IS 2571- 1970. The workmanship shall comply with IS 3025:1983

- The sub base shall be of sand, PCC
- If the base surface is Cement concrete shall be placed in position and beaten with trowel till the surface is found covered with cream of mortar.

Vacuum Dewatered Concrete Flooring

Concrete is poured in place and vibrated with a poker vibrator.

Polished Slab Granite flooring

Polished granite slab shall be machine cut. Machine cut slabs shall have fine tooled dressing on all sides to full depth. Slabs shall be washed clean before laying. The bedding mortar of the specified mix shall be spread under each slab, slab shall be then laid on top, pressed so that the hollows underneath get filled and surplus mortar works up through the joints. The slabs should be tapped with wooden mallet and brought to level and close to adjoining slabs with thickness of joints not exceeding 1.5 mm. After laying each slab surplus mortar on the surface of the slabs shall be cleaned off and joint finished flush. Subsequent slabs shall be laid in the same manner. The joint shall be left raked out uniformly to a depth not less than 10 mm, when the mortar is still green. The surface of the flooring laid, shall be true to levels as directed by the Engineer-in-Charge. Slabs, which are fixed in the floor and joints the wall not less than 12 mm under the plaster, and floor shall be finished neatly and without waviness.

The flooring shall be cured for Fourteen days. The finished floor shall not sound hollow when tapped with wooden mallet. Measurement shall be on Sq. mt. basis. The rate shall include cost of all materials, labour and shuttering involved in all the operations.

Glazed Earthenware/Tiles/Ceramic Tile Flooring, Dado and Skirting

Glazed earthenware tile shall conform to I.S. 777-1970, specification for glazed earthenware tiles. When fractured they shall appear fine grained in texture, dense and homogeneous. The tile shall be flat true to shape, sound and free from flaws and other manufacturing defects.

Facial dimensions: The length of all the four sides of tiles shall be measured to the nearest 0.1 mm. The average value shall not vary more than + or – 0.8 mm from the dimension of the nominal size. The variation of the individual dimension from the average value shall not exceed + or – 0.5 mm.

Tolerance on thickness + or – 0.5 mm.

Water absorption: The average water absorption of the tile when tested and evaluated shall exceed 18 percent.

Impact strength: Tiles when tested for impact strength shall not have a value less than 0.020 Kg fm/cm.

Bedding over which the glaze tiles shall be laid as indicated and shall not be less than 10 mm at any place. Mix of bedding layer should be as specified. Tiles shall be soaked in water before laying.

Base shall be cleaned and wetted. The bedding shall then be laid evenly over the surface, tamped and corrected to desired levels and allow to harden enough to offer a rigid cushion to tiles. Before laying the tiles, cement slurry of honey like consistency 3 Kg /Sq. mt. shall be applied over the bedding. At a time, area to accommodate about 20 tiles shall be applied with cement slurry. Tiles shall then the washed clean and fixed in the grout one after the other. Each tile being gently tapped in its position till it is properly bedded and in level and line with adjoining tiles. The joint shall be as thin as possible but not exceeding 1.5 mm wide.

In the case of skirting and dado, the wall surface shall be covered with about 10 mm thick plaster of cement and sand mortar 1:3 and allow to harden. The plaster shall be roughened with wire brushes or by scratching diagonal lines. The back of the tiles shall be buttered with cement paste and set on bedding mortar. The tiles shall be gently tapped in position one after the other. Top of skirting or dado shall be truly horizontal and the joints vertical or as per required pattern.

The joints shall be racked to a depth of 5 mm and all dust and loose mortar removed. Joints shall then be flush pointed in White cement or in coloured cement in the case of coloured tiles. The surface shall be cured for seven days and then wash clean.

Mode of Measurement: Payment will be on Sq. mt. basis. Rate shall include cost of all materials labour and shuttering involved in all the operations.

Painting

The following I.S. apply to this section;

I.S. NO.	SUBJECT
5410-1969	Specification for cement paint,colour as required.
2932-1974	Enamel, synthetic, exterior, under coating and finishing (First Revision)

CEMENT PAINT

Cement paint shall comply with I.S. 5410-1969, specification for cement paint, colour as required. The material shall be in powder form, free from lumps that are not friable and when mixed with required volume of water shall be suitable for use on porous surface of masonry, concrete and rough plaster work.

PAINTING WOODWORK

Paint shall comply with IS 3915:1984.All woodwork shall be dried free from dust, dirt or any extraneous materials. Flat portion shall be smoothened with abrasive paper used across the grain prior to painting. All loose knots removed, and holes filled.

PAINTING STEEL AND IRON WORK

- Paint shall comply with IS 1573:1993
- The surface shall be thoroughly cleaned of dirt, fluxing material, other foreign material.
- Temporary rust protective materials applied to steel sheets to protect during transport and storage shall be removed with suitable solvent as a preliminary to other preparatory treatment.
- Surfaces already pretreated or primed in a factory shall be carefully inspected and damage areas shall be thoroughly degreased and cleaned of all dust and touch up.
- Priming coat shall be applied by brush, working in the paint into the fine dents and ensuring a continuous film without runs and holds.
- After the primer coat is harden and dry, Deep dents and scratches, if any shall be filled with paste
- Under coating shall be applied by brush. The film shall be allowed to hard dry, wet rubbed and cut down to a smooth finish ensuring that at no place under coat is completely removed.
- Finishing coat shall be applied for brush. Special care shall be taken while painting over bolts, nuts, rivets and overlaps etc.
- The painted surfaces shall present a uniform appearance and from streaks, blisters etc.

Schedule - E

(See Clauses 2.1 and 14.2)

Maintenance Requirements

1. Maintenance Requirements

(i) The Contractor shall, at all times maintain the Project Road in accordance with the provisions of this Agreement, Applicable Laws and Applicable Permits.

(ii) The Contractor shall repair or rectify any Defect or deficiency set forth in Paragraph 2 of this Schedule-E within the time limit specified therein and any failure in this behalf shall constitute non-fulfilment of the Maintenance obligations by the Contractor. Upon occurrence of any breach hereunder, the Authority shall be entitled to effect reduction in monthly lump sum payment as set forth in Clause 14.6 of this Agreement, without prejudice to the rights of the Authority under this Agreement, including Termination thereof.

(iii) All Materials, works and construction operations shall conform to the MORTH Specifications for Road and Bridge Works, and the relevant IRC publications. Where the specifications for a work are not given, Good Industry Practice shall be adopted.

2. Repair/rectification of Defects and deficiencies

The obligations of the Contractor in respect of Maintenance Requirements shall include repair and rectification of the Defects and deficiencies specified in Annex - I of this Schedule-E within the time limit set forth therein.

3. Other Defects and deficiencies

In respect of any Defect or deficiency not specified in Annex - I of this Schedule-E, the Authority's Engineer may, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Specifications and Standards, and any deviation or deterioration beyond the permissible limit shall be repaired or rectified by the Contractor within the time limit specified by the Authority's Engineer.

4. Extension of time limit

Notwithstanding anything to the contrary specified in this Schedule-E, if the nature and extent of any Defect or deficiency justifies more time for its repair or rectification than the time specified herein, the Contractor shall be entitled to additional time in conformity with Good Industry Practice. Such additional time shall be determined by the Authority's Engineer and conveyed to the Contractor and the Authority with reasons thereof.

5. Emergency repairs/restoration

Notwithstanding anything to the contrary contained in this Schedule-E, if any Defect, deficiency or deterioration in the Project Road poses a hazard to safety or risk of damage to property, the Contractor shall promptly take all reasonable measures for eliminating or minimizing such danger.

6. Daily inspection by the Contractor

The Contractor shall, through its engineer, undertake a daily visual inspection of the Project Road and maintain a record thereof in a register to be kept in such form and manner as the Authority's Engineer may specify. Such record shall be kept in safe custody of the Contractor and shall be open to inspection by the Authority and the Authority's Engineer at any time during office hours.

7. Pre-monsoon inspection / Post-monsoon inspection

The Contractor shall carry out a detailed pre-monsoon inspection of all bridges, culverts and drainage system before [1st June] every year in accordance with the guidelines contained in IRC: SP35. Report of this inspection together with details of proposed maintenance works as required on the basis of this inspection shall be sent to the Authority's Engineer before the 10th May every year. The Contractor shall complete the required repairs before the onset of the monsoon and send to the Authority's Engineer a compliance report. Post monsoon inspection shall be done by the 30th September and the inspection report together with details of any damages observed and proposed action to remedy the same shall be sent to the Authority's Engineer.

8. Repairs on account of natural calamities

All damages occurring to the Project Road on account of a Force Majeure Event or wilful default or neglect of the Authority shall be undertaken by the Authority at its own cost. The Authority may instruct the Contractor to undertake the repairs at the rates agreed between the Parties.

Annex – I

(Schedule-E)

Repair/rectification of Defects and deficiencies

The Contractor shall repair and rectify the Defects and deficiencies specified in this Annex-I of Schedule-E within the time limit set forth in the table below.

Table -1: Maintenance Criteria for Pavements:

Asset Type	Performance Parameter	Level of Service (LOS)		Frequency of Inspection	Tools/Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specifications
		Desirable	Acceptable					
Flexible Pavement (Pavement of MCW, Service Road, approache	Potholes	Nil	< 0.1 % of area and subject to limit of 10 mm in depth	Daily	Length Measurement Unit like Scale, Tape, odometer etc.	IRC 82: 2015 and Distress Identification Manual for Long Term Pavement Performance Program, FHWA 2003 (http://www.tfhrc.com/pavement/lttp/reports/03031/)	24-48 hours	MORT&H Specification 3004.2

Asset Types of Grade structure, approaches of connecting roads, slip roads, lay byes etc. as applicable)	Performance Parameter	Level of Service (LOS)		Frequency of Inspection	Tools/Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specifications
		Desirable	Acceptable					
	Cracking	Nil	< 5 % subject to limit of 0.5 sqm for any 50 m length	Daily			7-15 days	MORT&H Specification 3004.3
	Rutting	Nil	< 5 mm	Daily	Straight Edge		15 -30 days	MORT&H Specification 3004.2
	Corrugations and Shoving	Nil	< 0.1 % of area	Daily	Length Measurement Unit like		2-7 days	IRC:82-2015

Asset Type	Performance Parameter	Level of Service (LOS)		Frequency of Inspection	Tools/Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specifications
		Desirable	Acceptable					
	Bleeding	Nil	< 1 % of area	Daily	Scale, Tape, odometer etc.		3-7 days	MORT&H Specification 3004.4
	Ravelling / Stripping	Nil	< 1 % of area	Daily			7-15 days	IRC:82-2015 read with IRC SP 81
	Edge Deformation/ Breaking	Nil	< 1 m for any 100 m section and width < 0.1 m at any location, restricte	Daily			7- 15 days	IRC:82-2015

Asset Type	Performance Parameter	Level of Service (LOS)		Frequency of Inspection	Tools/Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specifications
		Desirable	**Acceptable**					
			d to 30 cm from the edge					
	Roughness BI	2000 mm/km	2400 mm/km	Bi-Annually	Class I Profilometer SCRIM (Sideway-force Coefficient Routine Investigation Machine or equivalent)	Class I Profilometer : ASTM E950 (98) :2004 –Standard Test Method for measuring Longitudinal Profile of Travelled Surfaces with Accelerometer Established Inertial Profiling Reference ASTM E1656 -94: 2000- Standard Guide for Classification of Automatic Pavement Condition Survey Equipment	180 days	IRC:82-2015
	Skid Number	60SN	50SN	Bi-Annually			180 days	BS: 7941-1: 2006
	Pavement Condition Index	3	2.1	Bi-Annually			180 days	IRC:82-2015

Asset Type	Performance Parameter	Level of Service (LOS)		Frequency of Inspection	Tools/Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specifications
		Desirable	Acceptable					
	Other Pavement Distresses			Bi-Annually			2-7 days	IRC:82-2015
	Deflection/ Remaining Life			Annually	Falling Weight Deflectometer	IRC 115: 2014	180 days	IRC:115-2014
Rigid Pavement (Pavement of MCW, Service Road, Grade structure,	Roughness BI	2200mm/km	2400mm/km	Bi-Annually	Class I Profilometer	ASTM E950 (98) :2004 and ASTM E1656 - 94: 2000	180 days	IRC:SP:83-2008
	Skid	Skid Resistance no. at different speed of vehicles		Bi-Annually	SCRIM (Sideway-force	IRC:SP:83-2008	180 days	IRC:SP:83-2008

<table>
<tr><td rowspan="3">Asset Type approaches of connecting roads, slip roads, lay byes etc. as applicable)</td><td rowspan="2">Performance Parameter</td><td colspan="2">Level of Service (LOS)</td><td>Frequency of Inspection</td><td>Tools/Equipment</td><td>Standards and References for Inspection and Data Analysis</td><td>Time limit for Rectification/ Repair</td><td>Maintenance Specifications</td></tr>
<tr><td>Desirable</td><td>Acceptable</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>Minimum SN</td><td>Traffic Speed (Km/h)</td><td></td><td>Coefficient Routine Investigation Machine or equivalent)</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>36</td><td>50</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>33</td><td>65</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>32</td><td>80</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>31</td><td>95</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>31</td><td>110</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Asset Type	Performance Parameter	Level of Service (LOS)		Frequency of Inspection	Tools/Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specifications
		Desirable	Acceptable					
Embankment/ Slope	Edge drop at shoulders	Nil	40mm	Daily	Length Measurement Unit like Scale, Tape, odometer etc.	IRC	7-15 days	MORT&H Specification 408.4
	Slope of camber/cross fall	Nil	<2% variation in prescribed slope of camber/cross fall	Daily			7-15 days	MORT&H Specification 408.4
	Embankment Slopes	Nil	<15 % variation in prescribe	Daily			7-15 days	MORT&H Specification 408.4

Asset Type	Performance Parameter	Level of Service (LOS)		Frequency of Inspection	Tools/Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specifications
		Desirable	Acceptable					
			side slope					
	Embankment Protection	Nil	Nil	Daily	NA		7-15 days	MORT&H Specification
	Rain Cuts/ Gullies in slope	Nil	Nil	Daily Specially During Rainy Season	NA		7-15 days	MORT&H Specification

In addition to the above performance criterion, the contractor shall strictly maintain the rigid pavements as per requirements in the following table

Table -2: **Maintenance Criteria for Rigid Pavements:**

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	For the case d > D/2
CRACKING						
1	**Single Discrete Cracks Not intersecting with any joint**	w = width of crack L = length of crack d = depth of crack D = depth of slab	0	Nil, not discernible	No Action	Not applicable
			1	w < 0.2 mm. hair cracks		
			2	w = 0.2 - 0.5 mm, discernible from slow-moving car	Seal without delay	Seal, and stitch if L > lm. Within 7days
			3	w = 0.5 - 1.5 mm, discernible from fast-moving car		

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	**For the case d > D/2**
			4	w = 1.5 - 3.0 mm	Seal, and stitch if L > l m. Within 7 days	Staple or Dowel Bar Retrofit, FDR for affected portion. Within 15days
			5	w > 3 mm.		
2	**Single Transverse (or Diagonal) Crack intersecting with one or more joints**	w = width of crack L = length of crack d = depth of crack D = depth of slab	0	Nil, not discernible	No Action	
			1	w < 0.2 mm, hair cracks	Route and seal with epoxy. Within 7 days	Staple or Dowel Bar Retrofit. Within 15days
			2	w = 0.2 - 0.5 mm, discernible from slow vehicle		
			3	w = 0.5 - 3.0 mm, discernible from fast vehicle	Route, seal and stitch, if L > 1 m. Within 7 days	

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	**For the case d > D/2**
			4	w = 3.0 - 6.0 mm	Dowel Bar Retrofit. Within 15 days	Full Depth Repair Dismantle and reconstruct affected. Portion with norms and specifications - See Para 5.5 & 9.2 Within 15days
			5	w > 6 mm, usually associated with spalling, and/or slab rocking under traffic	Not Applicable, as it may be full depth	
3	**Single Longitudinal Crack intersecting with one or more joints**	w = width of crack L = length of crack d = depth of crack D = depth of slab	0	Nil, not discernible	No Action	
			1	w < 0.5 mm, discernable from slow moving vehicle	Seal with epoxy, if L > 1 m. Within 7 days	Staple or dowel bar retrofit. Within 15days

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	For the case d > D/2
			2	w = 0.5 - 3.0 mm, discernible from fast vehicle	Route seal and stitch, if L > l m. Within 15 days	-
			3	w = 3.0 - 6.0 mm	Staple, if L > 1 m. Within 15 days	Partial Depth Repair with stapling. Within 15 days
			4	w = 6.0 - 12.0 mm, usually associated with spalling	Not Applicable, as it may be full depth	
			5	w > 12 mm, usually associated with spalling, and/or slab rocking under traffic		Full Depth Repair Dismantle and reconstruct affected portion as per norms and specifications -

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	**For the case d > D/2**
						See Para 5.6.4 Within 15 days
4	**Multiple Cracks intersecting with one or more joints**	**w = width of crack**	0	Nil, not discernible	No Action	-
			1	w < 0.2 mm, hair cracks	Seal, and stitch if L > l m. Within 15 days	
			2	w = 0.2 - 0.5 mm. discernible from slow vehicle		
			3	w = 0.5 - 3.0 mm, discernible from fast vehicle	Full depth repair within 15 days	Dismantle, Reinstate subbase, Reconstruct whole slab as per specifications within 30 days
			4	w = 3.0 - 6.0 mm panel broken into 2 or 3 pieces		
			5	w > 6 mm and/or panel broken		

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	For the case d > D/2
				into more than 4 pieces		
5	**Corner Break**	w = width of crack L = length of crack	0	Nil, not discernible	No Action	-
			1	w < 0.5 mm; only 1 corner broken	Seal with low viscosity epoxy to secure broken parts Within 7 days	Seal with epoxy seal with epoxy Within 7days
			2	w < 1.5 mm; L < 0.6 m, only one corner broken		
			3	w < 1.5 mm; L < 0.6 m, two corners broken	Partial Depth (Refer Figure 8.3 of IRC:SP: 83-2008) Within 15 days	Full depth repair
			4	w > 1.5 mm; L > 0.6 m or three corners broken		
			5	ree or four corners broken		Reinstate sub-base, and reconstruct the

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	**For the case d > D/2**
						slab as per norms and specifications within 30days
6	**Punchout (Applicable to Continuous Reinforced Concrete Pavement (CRCP) only)**	w = width of crack L = length (m/m2)	0	Nil, not discernible		No Action
			1	w < 0.5 mm; L < 3 m/m^2	Not Applicable, as it may be full depth	Seal with low viscosity epoxy to secure broken parts. Within 15days
			2	either w > 0.5 mm or L < 3 m/m^2		
			3	w > 1.5 mm and L < 3 m/m^2		
			4	w > 3 mm, L < 3 m/m^2 and deformation		Full depth repair - Cut out and replace damaged area taking care not to damage reinforcement. Within 30days
			5	w > 3 mm, L > 3 m/m^2 and deformation		

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	For the case d > D/2
Surface Defects						
7	Ravelling or Honeycomb type surface	r = area damaged surface/total surface of slab (%) h = maximum depth of damage	0	Nil, not discernible	**Short Term**	**Long Term**
					No action.	Not Applicable
			1	r < 2 %	Local repair of areas damaged	
			2	r = 2 - 10 %	and liable to be damaged. Within 15 days	
			3	r = 10-25%	Bonded Inlay, 2 or 3 slabs if	
			4	r = 25 - 50 %	affecting.	

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	**For the case d > D/2**
					Within 30 days	
			5	r > 50% and h > 25 mm	Reconstruct slabs, 4 or more slabs if affecting. Within 30 days	
8	**Scaling**	r = damaged surface/total surface of slab (%) h = maximum depth of damage	0	Nil, not discernible	**Short Term**	**Long Term**
					No action.	Not Applicable
			1	r < **2 %**	Local repair of areas damaged and liable to be damaged. Within 7days	
			2	r = 2 - 10 %		

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	For the case d > D/2
			3	r = 10 - 20%	Bonded Inlay within 15 days	
			4	r = 20 - 30 %		
			5	r > 30 % and h > 25 mm	Reconstruct slab within 30 days	
9	**Polished Surface/Glazing**	t = texture depth, sand patch test	0		No action.	Not Applicable
			1	t > 1 mm		
			2 '	t = 1 - 0.6 mm	Monitor rate of deterioration	
			3	t = 0.6 - 0.3 mm		
			4	t = 0.3 - 0.1 mm		

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	For the case d > D/2
			5	t < 0.1 mm	Diamond Grinding if affecting 50% or more slabs in a continuous stretch of minimum 5 km. Within 30 days	
10	**Popout (Small Hole), Pothole Refer Para 8.4**	n = number/m^2 d = diameter h = maximum depth	0	d < 50 mm; h < 25 mm; n < 1 per 5 m^2	No action.	Not Applicable
			1	d = 50 - 100 mm; h < 50 mm; n < 1 per 5 m^2	Partial depth repair 65 mm deep. Within 15 days	
			2	d = 50 - 100 mm; h > 50 mm; n < 1 per 5 m^2		

S.No.	Type of Distress	Measured Parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d < D/2	For the case d > D/2
			3	d = 100 - 300 mm; h < 100 mm n < 1 per 5 m^2	Partial depth repair 110mm i.e.10 mm more than the depth of the hole. Within 30 days	
			4	d = 100 - 300 mm; h > 100 mm; n < 1 per 5 m^2		
			5	d > 300 mm; h > 100 mm: n > 1 per 5 m^2	Full depth repair. Within 30 days	

Joint Defects						
11	**Joint Seal Defects**	loss or damage L = Length as % total joint length	0	Difficult to discern.	**Short Term** No action.	**Long Term** Not Applicable
			1	Discernible, L< 25% but of little immediate consequence with regard to ingress of water or trapping incompressible material.	Clean joint, inspect later.	
			3	Notable. L > 25% insufficient protection against ingress of water and trapping incompressible material.	Clean and reapply sealant in selected locations. Within 7 days	
			5	Severe; w > 3 mm negligible protection against ingress of water	Clean, widen and reseal the joint. Within 7 days	

				and trapping incompressible material.		
12	**Spalling of Joints**	w = width on either side of the joint L = length of spalled portion (as % joint length)	0	Nil, not discernible	No action.	Not Applicable
			1	w < 10 mm	Apply low viscosity epoxy resin/ mortar in cracked portion.	
			2	w = 10 - 20 mm, L < 25%	Within 7 days	
			3	w = 20 - 40 mm, L > 25%	Partial Depth Repair. Within 15 days	
			4	w = 40 - 80 mm, L > 25%	30 - 50 mm deep, h = w + 20% of w, within 30 days	
			5	w > 80 mm, and L > 25%	50 - 100 mm deep repair. H = w + 20% of w. Within 30 days	
13	**Faulting (or Stepping)**	f = difference of level	0	not discernible, < 1 mm	No action.	No action.

	in Cracks or Joints		1	f < 3 mm		
			2	f = 3 - 6 mm	Determine cause and observe, take action for diamond grinding	Replace the slab as appropriate. Within 30days
			3	f = 6 - 12 mm	Diamond Grinding	
			4	f= 12 - 18 mm	Raise sunken slab.	Replace the slab as appropriate. Within 30days
			5	f> 18 mm	Strengthen subgrade and sub-base by grouting and raising sunken slab	
14	**Blowup or Buckling**	h = vertical displacement from normal profile	0	Nil, not discernible	**Short Term**	**Long Term**
					No Action	
			1	h < 6 mm		
			2	h = 6 - 12 mm	Install Signs to Warn Traffic	

			3	h = 12 - 25 mm	within 7 days	
			4	h > 25 mm	Full Depth Repair. Within 30 days	
			5	shattered slabs, ie 4 or more pieces	Replace broken slabs. Within 30 days	
15	**Depression**	h = negative vertical displacement from normal profile L =length	0	Not discernible, h < 5 mm	No action.	Not Applicable
			1	h = 5 - 15 mm		
			2	h = 15-30 mm, Nos <20% joints	Install Signs to Warn Traffic within 7 days	
			3	h = 30 - 50 mm		
			4	h > 50 mm or > 20% joints	Strengthen subgrade. Reinstate pavement at normal level	

			5	h > 100 mm	if L < 20 m. Within 30 days	
16	**Heave**	h = positive vertical displacement from normal profile. L = length	0	Not discernible. h < 5 mm	**Short Term**	**Long Term**
					No action.	scrabble
			1	h = 5 - 15 mm	Follow up.	
			2	h = 15 - 30 mm, Nos <20% joints	Install Signs to Warn Traffic within 7 days	
			3	h = 30 - 50 mm		
			4	h > 50 mm or > 20% joints	Stabilize subgrade. Reinstate pavement at normal level if length < 20 m. Within 30 days	
			5	h > 100 mm		
17	**Bump**	h = vertical	0	h < 4 mm	No action	

		displacement from normal profile	1	h = 4 - 7 mm	Grind, in case of new construction within 7 days	Construction Limit for New Construction.
			3	h = 7 - 15 mm	Grind, in case of ongoing Maintenance within 15 days	Replace in case of new construction. Within 30days
			5	h > 15 mm	Full Depth Repair. Within 30 days	Full Depth Repair. Within 30days
18	**Lane to Shoulder Dropoff**	f = difference of level	0	Nil, not discernible < 3mm	**Short Term**	**Long Term**
					No action.	
			1	f = 3 - 10 mm	Spot repair of shoulder within 7 days	
			2	f = 10 - 25 mm		
			3	f = 25 - 50 mm	Fill up shoulder	

			4	f = 50 - 75 mm	within 7 dayss	For any 100 m stretch Reconstruct shoulder, if affecting 25% or more of stretch. Within 30days
			5	f > 75 mm		
Drainage						
19	**Pumping**	quantity of fines and water expelled through open joints and cracks Nos	0	not discernible	No Action	
			1 to 2	slight/ occasional Nos < 10%	Repair cracks and joints Without delay.	Inspect and repair sub-drainage at distressed sections and upstream.
			3 to 4	appreciable/ Frequent 10 - 25%	Lift or jack slab within 30 days.	
		Nos/100 m stretch	5	abundant, crack development > 25%	Repair distressed pavement sections. Strengthen subgrade and subbase. Replace slab. Within 30 days	

20	**Ponding**	Ponding on slabs due to blockage of drains	0-2	No discernible problem	No action.	
			3 to 4	Blockages observed in drains, but water flowing	Clean drains etc within 7 days, Follow up	Action required to stop water damaging foundation within 30 days.
			5	Ponding, accumulation of water observed	-do-	

Table -3: Maintenance Criteria for Safety Related Items and Other Furniture Items:

<table>
<tr><th>Asset Type</th><th>Performance Parameter</th><th colspan="3">Level of Service (LOS)</th><th>Frequency of Measurement</th><th>Testing Method</th><th colspan="2">Recommended Remedial measures</th><th>Specifications and Standards</th></tr>
<tr><td rowspan="5">Road</td><td rowspan="5">Availability of Safe Sight Distance</td><td colspan="3">As per IRC SP :84-2014, a minimum of safe stopping sight distance shall be available throughout.</td><td rowspan="5">Monthly</td><td rowspan="5">Manual Measurements with Odometer along with video/ image backup</td><td colspan="2" rowspan="5">Removal of obstruction within 24 hours, in case of sight line affected by temporary objects such as trees, temporary encroachments.

In case of permanent structure or design deficiency:
Removal of obstruction/improvement of deficiency at the earliest
Speed Restriction boards and suitable traffic calming measures such as transverse bar marking, blinkers, etc. shall be applied during the period of rectification.</td><td rowspan="5">IRC:SP 84-2014</td></tr>
<tr><td>Design Speed, kmph</td><td>Desirable Minimum Sight Distance (m)</td><td>Safe Stopping Sight Distance (m)</td></tr>
<tr><td>100</td><td>360</td><td>180</td></tr>
<tr><td>80</td><td>260</td><td>130</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Pavement Marking</td><td>Wear</td><td colspan="3"><70% of marking remaining</td><td>Bi-Annually</td><td>Visual Assessment as per Annexure-F of IRC:35-2015</td><td>Re - painting</td><td>Cat-1 Defect – within 24 hours
Cat-2 Defect - within 2 months</td><td>IRC:35-2015</td></tr>
</table>

<table>
<tr><th>Asset Type</th><th>Performance Parameter</th><th>Level of Service (LOS)</th><th>Frequency of Measurement</th><th>Testing Method</th><th>Recommended Remedial measures</th><th>Time limit for Rectification</th><th>Specifications and Standards</th></tr>
<tr><td></td><td>Day time Visibility</td><td>During expected life Service Time
Cement Road - 130mcd/m²/lux
Bituminous Road - 100mcd/m²/lux</td><td>Monthly</td><td>As per Annexure-D of IRC:35-2015</td><td>Re - painting</td><td>Cat-1 Defect – within 24 hours
Cat-2 Defect – within 2 months</td><td>IRC:35-2015</td></tr>
<tr><td></td><td>Night Time Visibility</td><td><u>Initial and Minimum Performance for Dry Retro reflectivity during night time:</u>
<table>
<tr><th>Design Speed</th><th colspan="2">(RL) Retro Reflectivity (mcd/m²/lux)</th></tr>
<tr><td></td><td>Initial (7 days)</td><td>Minimum Threshold level (TL) & warranty period required up to 2 years</td></tr>
<tr><td>Up to 65</td><td>200</td><td>80</td></tr>
<tr><td>65 - 100</td><td>250</td><td>120</td></tr>
<tr><td>Above 100</td><td>350</td><td>150</td></tr>
</table>
<u>Initial and Minimum Performance for Night Visibility under wet condition (Retro reflectivity):</u></td><td>Bi-Annually</td><td>As per Annexure-E of IRC:35-2015</td><td>Re - painting</td><td>Cat-1 Defect – within 24 hours
Cat-2 Defect – within 2 months</td><td>IRC:35-2015</td></tr>
</table>

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specifications and Standards
		Initial 7 days Retro reflectivity: 100 mcd/m²/lux Minimum Threshold Level: 50 mcd/m²/lux					
	Skid Resistance	Initial and Minimum performance for Skid Resistance: Initial (7days): 55BPN Min. Threshold: 44BPN *Note: shall be considered under urban/city traffic condition encompassing the locations like pedestrian crossings, bus bay, bus stop, cycle track intersection delineation, transverse bar markings etc	Bi-Annually	As per Annexure-G of IRC:35-2015		Within 24 hours	IRC:35-2015
Road Signs	Shape and Position	Shape and Position as per IRC:67-2012. Signboard should be clearly visible for the design speed of the section.	Daily	Visual with video/image backup	Improvement of shape, in case if shape is damaged. Relocation as per requirement	48 hours in case of Mandatory Signs, Cautionary and Informatory Signs (Single and Dual post signs) 15 Days in case of Gantry/Cantilever Sign boards	IRC:67-2012
	Retro reflectivity	As per specifications in IRC:67-2012	Bi-Annually	Testing of each	hange of ignboard	48 hours in case of Mandatory	RC:67-2012

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specifications and Standards
				signboard using Retro Reflectivity Measuring Device. In accordance with ASTM D 4956-09.		Signs, Cautionary and Informatory Signs (Single and Dual post signs) 1 Month in case of Gantry/Cantilever Sign boards	
Kerb	Kerb Height	As per IRC 86:1983 depending upon type of Kerb	Bi-Annually	Use of distance measuring tape	Raising Kerb Height	Within 1 Month	RC 86:1983
	Kerb Painting	Functionality: Functioning of Kerb painting as intended	Daily	Visual with video/image backup	Kerb Repainting	Within 7-days	RC 35:2015
Other Road Furniture	Reflective Pavement Markers (Road Studs)	Numbers and Functionality as per specifications in IRC:SP:84-2014 and IRC:35-2015, unless specified in Schedule-B.	Daily	Counting	New Installation	Within 2 months	IRC:SP:84-2014, IRC:35-2015
	Pedestrian Guardrail	Functionality: Functioning of guardrail as intended	Daily	Visual with video/image backup	Rectification	Within 15 days	IRC:SP:84-2014
	Traffic Safety Barriers	Functionality: Functioning of Safety Barriers as intended	Daily	Visual with video/image backup	Rectification	Within 7 days	IRC:SP:84-2014, IRC:119-2015
	End Treatment of	Functionality: Functioning of End Treatment as intended	Daily	Visual with video/image	Rectification	Within 7 days	IRC:SP:84-2014,

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specifications and Standards
	Traffic Safety Barriers			backup			IRC:119-2015
	Attenuators	Functionality: Functioning of Attenuators as intended	Daily	Visual with video/image backup	Rectification	Within 7 days	IRC:SP-2014, IRC:119-2015
	Guard Posts and Delineators	Functionality: Functioning of Guard Posts and Delineators as intended	Daily	Visual with video/image backup	Rectification	Within 15 days	IRC: 79 - 1981
	Overhead Sign Structure	Overhead sign structure shall be structurally adequate	Daily	Visual with video/image backup	Rectification	Within 15 days	IRC:67-2012
	Traffic Blinkers	Functionality: Functioning of Traffic Blinkers as intended	Daily	Visual with video/image backup	Rectification	Within 7 days	IRC:SP:84-2014
Road Lighting System	Road Lights	Illumination: Minimum 40 Lux illumination on the road surface	Daily	The illumination level shall be measured with luxmeter	Improvement in Lighting System	24 hours	IRC:SP:84-2014
		No major failure in the lighting system	Daily	-	Rectification of failure	24 hours	IRC:SP:84-2014
		No minor failure in the lighting system	Monthly	-	Rectification of failure	8 hours	IRC:SP:84-2014
	Toll Plaza Canopy Lights	Minimum 40 Lux illumination on the road surface	Daily	The illumination level shall be measured with luxmeter	Improvement in Lighting System	24 hours	IRC:SP:84-2014
		No major/minor failure in the lighting system	Daily	-	Rectification of failure	8 hours	IRC:SP:84-2014

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specifications and Standards
Trees and Plantation including median plantation	Obstruction in a minimum head-room of 5.5 m above carriageway or obstruction in visibility of road signs	No obstruction due to trees	Monthly	Visual with video/image backup	Removal of trees	Immediate	IRC:SP:84-2014
	Deterioration in health of trees and bushes	Health of plantation shall be as per requirement of specifications & instructions issued by Authority from time to time	Daily	Visual with video/image backup	Timely watering and treatment. Or Replacement of Trees and Bushes.	Within 90 days	IRC:SP:84-2014
	Vegetation affecting sight line and road structures	Sight line shall be free from obstruction by vegetation	Daily	Visual with video/image backup	Removal of Trees	Immediate	IRC:SP 84-2014
Rest Areas	Cleaning of toilets	-	Daily	-	-	Every 4 hours	
	Defects in electrical, water and sanitary installations	-	Daily	-	Rectification	24 hours	

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended zRemedial measures	Time limit for Rectification	Specifications and Standards
Other Project Facilities and Approach roads	Damage or deterioration in Approach Roads, pedestrian facilities, truck lay-bys, bus-bays, bus-shelters, cattle crossings, Traffic Aid Posts, Medical Aid Posts and other works		Daily	-	Rectification	15 days	IRC:SP 84-2014

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial measures	Time limit for Rectification	Specifications and Standards
Pipe/box/slab culverts	Free waterway/ unobstructed flow section	85% of culvert normal flow area to available.	2 times in a year (before and after rainy season)	Inspection by Bridge Engineer as per IRC SP: 35-1990 and recording of depth of silting and area of vegetation.	Cleaning silt up soils and debris in culvert barrel after rainy season, removal of bushes and vegetation, U/s of barrel, under barrel and D/s of barrel before rainy season.	15 days before onset of monsoon and within 30 days after end of rainy season.	IRC 5-2015, IRC SP:40-1993 and IRC SP:13-2004
	Leak-proof expansion joints if any	No leakage through expansion joints	Bi-Annually	Physical inspection of expansion joints as per IRC SP: 35-1990 if any, for leakage strains on walls at joints.	Fixing with sealant suitably	30 days or before onset of rains whichever comes earlier	IRC SP:40-1993 and IRC SP:69-2011
	Structurally sound	Spalling of concrete not more than 0.25 sqm	Bi-Annually	Detailed inspection of all components of culvert as per IRC SP:35-1990 and recording the defects	Repairs to spalling, cracking, delamination, rusting shall be followed as per IRC:SP:40-1993.	15 days	IRC SP 40-1993 and MORTH Specifications clause 2800
		Delamination of concrete not more than 0.25 sq.m.					

		Cracks wider than 0.3 mm not more than 1m aggregate length					

	Protection works in good condition	Damaged of rough stone apron or bank revetment not more than 3 sqm, damage to solid apron (concrete apron) not more than 1 sqm	2 times in a year (before and after rainy season)	Condition survey as per IRC SP:35-1990	Repairs to damaged aprons and pitching	30 days after defect observation or 2 weeks before onset of rainy season whichever is earlier.	IRC: SP 40-1993 and IRC:SP:13-2004.
Bridges including ROBs Flyover etc. as applicable	Riding quality or user comfort	No pothole in wearing coat on bridge deck	Daily	Visual inspection as per IRC SP:35-1990	Repairs to BC or wearing coat	15 days	MORT&H Specification 2811
Bridge -Super Structure	Bumps	No bump at expansion joint	Daily	Visual inspection as per IRC SP:35-1990	Repairs to BC on either side of expansion joints, profile correction course on approach slab in case of settlement to approach embankment	15 days	MORT&H Specification 3004.2 & 2811.
	User safety (condition of crash barrier and guard rail)	No damaged or missing stretch of crash barrier or pedestrian hand railing	Daily	Visual inspection and detailed condition survey as per IRC SP: 35-1990.	Repairs and replacement of safety barriers as the case may be	3days	IRC: 5-1998, IRC SP: 84-2014 and IRC SP: 40-1993.

	Rusted reinforcement	Not more than 0.25 sq.m	Bi-Annually	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	All the corroded reinforcement shall need to be thoroughly cleaned from rusting and applied with anti-corrosive coating before carrying out the repairs to affected concrete portion with epoxy mortar / concrete.	15 days	IRC SP: 40-1993 and MORTH Specification 1600.
	Spalling of concrete	Not more than 0.50 sq.m					
	Delamination	Not more than 0.50 sq.m					
	Cracks wider than 0.30 mm	Not more than 1m total length	Bi-Annually	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	Grouting with epoxy mortar, investigating causes for cracks development and carry out necessary rehabilitation.	48 Hours	IRC SP: 40-1993 and MORTH Specification 2800.
	Rainwater seepage through deck slab	Leakage - nil	Quarterly	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	Grouting of deck slab at leakage areas, waterproofing, repairs to drainage spouts	1 months	MORTH specifications 2600 & 2700.
	Deflection due to permanent loads and	Within design limits.	Once in every 10 years for spans more	Load test method	Carry out major rehabilitation works on bridge to retain original design loads capacity	6 months	IRC SP: 51-1999.

	live loads		than 40 m				
	Vibrations in bridge deck due to moving trucks	Frequency of vibrations shall not be more than 5 Hz	Once in every 5 years for spans more than 30m and every 10 years for spans between 15 to 30 m	Laser displacement sensors or laser vibro-meters	Strengthening of super structure	4 months	AASHTO LRFD specifications
	Leakage in Expansion joints	No damage to elastomeric sealant compound in strip seal expansion joint, no leakage of rain water through expansion joint in case of buried and asphalt plug and copper strip joint.	Bi-Annually	Detailed condition survey as per IRC SP:35-1990 using Mobile Bridge Inspection Unit	Replace of seal in expansion joint	15 days	MORTH specifications 2600 and IRC SP: 40-1993.
	Debris and dust in strip seal	No dust or debris in expansion joint	Monthly	Detailed condition survey as per IRC SP:35-1990 using	Cleaning of expansion joint gaps thoroughly	3 days	MORTH specifications 2600 and

	expansion joint	gap.		Mobile Bridge Inspection Unit			IRC SP: 40-1993.
	Drainage spouts	No down take pipe missing/broken below soffit of the deck slab. No silt, debris, clogging of drainage spout collection chamber.	Monthly	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	Cleaning of drainage spouts thoroughly. Replacement of missing/broken down take pipes with a minimum pipe extension of 500mm below soffit of slab. Providing sealant around the drainage spout if any leakages observed.	3 days	MORTH specification 2700.
Bridge-substructure	Cracks/spalling of concrete/ rusted steel	No cracks, spalling of concrete and rusted steel	Bi-Annually	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	All the corroded reinforcement shall need to be thoroughly cleaned from rusting and applied with anti-corrosive coating before carrying out repairs to substructure by grouting/guniting and micro concreting depending on type of defect noticed	30 days	IRC SP: 40-1993 and MORTH specification 2800.

	Bearings	Delamination of bearing reinforcement not more than 5%, cracking or tearing of rubber not more than 2 locations per side, no rupture of reinforcement or rubber	Bi-Annually	Detailed condition survey as per IRC SP: 35-1990 using Mobile Bridge Inspection Unit	In case of failure of even one bearing on any pier/abutment, all the bearings on that pier/abutment shall be replaced, in order to get uniform load transfer on to bearings.	3 months	MORTH specification 2810 and IRC SP: 40-199.
Bridge Foundations	Scouring around foundations	Scouring shall not be lower than maximum scour level for the bridge	Bi-Annually	Condition survey and visual inspection as per IRC SP:35-1990 using Mobile Bridge Inspection Unit. In case of doubt, use Underwater camera for inspection of deep wells in major Rivers.	Suitable protection works around pier/abutment	1 month	IRC SP: 40-1993, IRC 83-2014, MORTH specification 2500
	Protection works in good condition	Damaged of rough stone apron or bank revetment not more than 3	2 times in a year (before and after rainy season)	Condition survey as per IRC SP:35-1990	Repairs to damaged aprons and pitching.	30 days after defect observation or 2	IRC: SP 40-1993 and IRC:SP:13-2004.

		sq.m, damage to solid apron (concrete apron) not more than 1 sq.m			
Note: Any Structure during the entire contract period which is found that does not complies with a rehabilitated or even reconstructed under the scope of the contractor.					

Table 4: Maintenance Criteria for tunnel and structures:
(Urban Road Tunnel – Cut & Cover Method)

A. STRUCTURAL ELEMENTS

Sl. No.	Asset / Component	Performance Parameter	Desirable Level of Service (LOS-D)	Minimum Acceptable Level of Service (LOS-A)	Frequency of Inspection	Equipment Required	Standards / References
1	Concrete (roof, walls, base slab)	Crack Width	< 0.1 mm	≤ 0.3 mm	6 months, post-monsoon	Crack gauge, feeler	IRC:SP:167, IS 456, MoRTH 1700
2	Concrete Integrity	Sound, no delamination	Minor surface defects allowed; no structural distress	6 months	Rebound hammer, UPV	IS 13311, IS 15988	
3	Water Leakage	No active seepage	Dampness <1% area; no dripping	Quarterly	Moisture meter, visual	MoRTH 2700	
4	Structural Deformation	No visible deformation	Within design tolerances	Annual	Total station, scanner	IRC:SP:167	

B. WATERPROOFING & DRAINAGE

Sl. No.	Component	Performance Parameter	LOS-D	LOS-A	Frequency	Equipment	Reference
5	Waterproofing	Leakage	No leaks	Minor damp patches; no drips	6 months	Thermal camera	IS 16471
6	Longitudinal Drains	Flow capacity	100%	≥ 80%	Quarterly	CCTV drain camera	MoRTH 309
7	Sump Pumps	Pump discharge	100% discharge	≥ 90% discharge	Quarterly	Flow meter	IS 9137

C. PAVEMENT INSIDE TUNNEL

Sl. No.	Component	Parameter	LOS-D	LOS-A	Frequency	Equipment	Reference
8	Pavement	IRI (Roughness)	< 3.0 m/km	≤ 4.0 m/km	Annual	Bump integrator / Laser profiler	IRC:SP:16
9	Skid Resistance	BPN	> 55	≥ 45	6 months	BPT	IRC:SP:51
10	Rutting	Rut depth	< 5 mm	≤ 10 mm	Annual	Straightedge, laser	MoRTH 500

D. LIGHTING & ELECTRICAL SYSTEM

Sl. No.	Component	Parameter	LOS-D	LOS-A	Frequency	Equipment	Reference
11	Tunnel Lighting	Lux level	Meets IRC:SP:90	≥ 85% of design lux	Quarterly	Lux meter	IRC:SP:90
12	Emergency Lighting	Availability	100% operational	≥ 95%	Quarterly	Battery load tester	NFPA 502
13	Electrical System	Earth Resistance	< 1 ohm	≤ 2 ohm	6 months	Earth tester	IS 3043

E. VENTILATION SYSTEM

Sl. No.	Component	Parameter	LOS-D	LOS-A	Frequency	Equipment	Reference
14	Jet Fans / Ventilation	Air Velocity	Meets design	≥ 85% of design	Quarterly	Anemometer	NFPA 502
15	Fan Availability	Availability	100%	≥ 95%	Quarterly	Diagnostics	OEM Specs

F. FIRE & LIFE SAFETY SYSTEMS

Sl. No.	Component	Performance Parameter	LOS-D	LOS-A	Frequency	Equipment	Reference
16	Fire Hydrants	Pressure & Flow	100%	≥ 80%	6 months	Pressure gauge, flow meter	IS 13039, NBC-4
17	Fire Alarm System	Sensor operability	100%	≥ 98%	Quarterly	Detector tester	NFPA 72
18	Emergency Signage	Visibility / Function	All functioning	≥ 95%	Monthly	Visual	IRC:SP:55

G. ITS, COMMUNICATION & SAFETY EQUIPMENT

Sl. No.	Component	Parameter	LOS-D	LOS-A	Frequency	Equipment	Reference
19	CCTV System	Operational availability	100%	≥ 95%	Monthly	System diagnostics	ITS Standards
20	SOS Call Boxes	Availability	100%	≥ 95%	Monthly	Audio test	IEC 60840
21	SCADA	Functionality	Fully operational	≥ 98% uptime	Quarterly	SCADA audit tools	OEM / International

Sl. No.	Component	Parameter	LOS-D	LOS-A	Frequency	Equipment	Reference
							ITS

H. STRUCTURAL MONITORING

Sl. No.	Component	Parameter	LOS-D	LOS-A	Frequency	Equipment	Reference
22	Roof / Wall Deformation	Settlement & lateral movement	< 5 mm/year	≤ 10 mm/year	Annual	Laser scanning	IRC:SP:167
23	Structural Joints	Condition	No distress	Minor wear; sealed	6 months	Visual	IS 456

I. ENVIRONMENTAL PERFORMANCE

Sl. No.	Component	Parameter	LOS-D	LOS-A	Frequency	Equipment	Reference
24	Air Quality	CO Levels	< 50 ppm	≤ 70 ppm	Monthly	Air quality monitor	IRC:SP:90
25	Visibility	Sight Distance	> 120 m	≥ 80 m	Quarterly	Visibility meter	IRC:SP:90
26	Noise Levels	dB Levels	Within design	≤ 80 dB	Quarterly	Noise meter	CPCB norms

J. CLEANLINESS & OPERATION

Sl. No.	Component	Parameter	LOS-D	LOS-A	Frequency	Equipment	Reference
27	Tunnel Interior	Cleanliness	No dust; no debris	Dust < 3 mm, no hazardous debris	Monthly	Visual	O&M Manual
28	Drainage Pits	Sediment level	< 10% capacity	≤ 20% capacity	Monthly	Probe rod	MoRTH 309

<u>Note:</u> For all tables 1 to 4 above, latest BIS & IRC standards (even those not indicated herewith) along with MoRTH specifications and international codes for tunnels shall be binding for all maintenance activities.

A. Flexible Pavement

Nature of Defect or deficiency		Time limit for repair/ rectification
(b)	**Granular earth shoulders, side slopes, drains and culverts**	
(i)	Variation by more than 1 % in the prescribed slope of camber/cross fall (shall not be less than the camber on the main carriageway)	7 (seven) days
(ii)	Edge drop at shoulders exceeding 40 mm	7 (seven) days
(iii)	Variation by more than 15% in the prescribed side (embankment) slopes	30 (thirty) days
(iv)	Rain cuts/gullies in slope	7 (seven) days
(v)	Damage to or silting of culverts and side drains	7 (seven) days
(vi)	Desilting of drains in urban/semi- urban areas	24 (twenty four) hours
(vii)	Railing, parapets, crash barriers	7 (seven) days (Restore immediately if causing safety hazard)
(c)	**Road side furniture including road sign and pavement marking**	
(i)	Damage to shape or position, poor visibility or loss of retro- reflectivity	48 (forty eight) hours
(ii)	Painting of km stone, railing, parapets, crash barriers	As and when required/ Once every year
(iii)	Damaged/missing signs road requiring replacement	7 (seven) days
(iv)	Damage to road mark ups	7 (seven) days
(d)	**Road lighting**	
(i)	Any major failure of the system	24 (twenty four) hours
(ii)	Faults and minor failures	8 (eight) hours
(e)	**Trees and plantation**	

Nature of Defect or deficiency		Time limit for repair/ rectification
(i)	Obstruction in a minimum head- room of 5 m above carriageway or obstruction in visibility of road signs	24 (twenty four)hours
(ii)	Removal of fallen trees from carriageway	4 (four) hours
(iii)	Deterioration in health of trees and bushes	Timely watering and treatment
(iv)	Trees and bushes requiring replacement	30 (thirty) days
(v)	Removal of vegetation affecting sight line and road structures	15 (fifteen) days
(f) Rest area		
(i)	Cleaning of toilets	Every 4 (four) hours
(ii)	Defects in electrical, water and sanitary installations	24 (twenty four) hours
(g) [Toll Plaza]		
(h)	**Other Project Facilities and Approach roads**	
(i)	Damage in approach roads, pedestrian facilities, truck lay- byes, bus-bays, bus-shelters, cattle crossings, [Traffic Aid Posts, Medical Aid Posts] and service roads	15 (fifteen) days
(ii)	Damaged vehicles or debris on the road	4 (four) hours
(iii)	Malfunctioning of the mobile crane	4 (four) hours
Bridges		
(a) Superstructure		
(i)	Any damage, cracks, spalling/ scaling Temporary measures Permanent measures	within 48 (forty eight) hours within 15 (fifteen) days or as specified by the Authority's Engineer
(b) Foundations		

Nature of Defect or deficiency		Time limit for repair/ rectification
(i)	Scouring and/or cavitation	15 (fifteen) days
(c)	**Piers, abutments, return walls and wing walls**	
(i)	Cracks and damages including settlement and tilting, spalling, scaling	30 (thirty) days
(d)	**Bearings (metallic) of bridges**	
(i)	Deformation, damages, tilting or shifting of bearings	15 (fifteen) days Greasing of metallic bearings once in a year
(e)	**Joints**	
(i)	Malfunctioning of joints	15 (fifteen) days
(f)	**Other items**	
(i)	Deforming of pads in elastomeric bearings	7 (seven) days
(ii)	Gathering of dirt in bearings and joints; or clogging of spouts, weep holes and vent-holes	3 (three) days
(iii)	Damage or deterioration in kerbs, parapets, handrails and crash barriers	3 (three) days (immediately within 24 hours if posing danger to safety)
(iv)	Rain-cuts or erosion of banks of the side slopes of approaches	7 (seven) days
(v)	Damage to wearing coat	15 (fifteen) days
(vi)	Damage or deterioration in approach slabs, pitching, apron, toes, floor or guide bunds	30 (thirty) days
(vii)	Growth of vegetation affecting the structure or obstructing the waterway	15 (fifteen) days

RESPONSE TIME FOR DEFECT RECTIFICATION IN RESPECT OF TUNNEL

Category	Time Allowed for Rectification
Safety-Critical Systems (Fire, Ventilation, Lighting)	Immediate / 24 hours
Structural Defects (Cracks, Spalling)	7 days
Drainage / Water Leakage	3 days
ITS / CCTV / Communication	72 hours
Cleanliness / Housekeeping	24 hours

[Note: Where necessary, the Authority may modify the time limit for repair/rectification, or add to the nature of Defect or deficiency before issuing the bidding document, with the approval of the competent authority.]

Schedule - F

(See Clause 4.1 (vii)(a))

Applicable Permits

1. Applicable Permits

(i) The Contractor shall obtain, as required under the Applicable Laws, the following Applicable Permits:

i. Permission of the State Government for extraction of boulders from quarry;

ii. Permission of Village Panchayat and Pollution Control Board for installation of crushers;

iii. License for use of explosives;

iv. License from Inspector of factories or other competent authority for setting up Batching Plant;

v. Clearance of Pollution Control Board for setting up Batching Plant;

vi. Clearance of Village Panchayats and Pollution Control Board for Asphalt Plant;

vii. Clearance of Pollution Control Board for Asphalt Plant;

viii. Clearance of Pollution Control Board for installation of diesel generator sets;

ix. Fire safety clearance from fire authorities;

x. Permit for employing unskilled/semiskilled labor during day/night;

xi. Permission of Village Panchayat and State Government for borrow earth;

xii. Permission of City Authorities for disposal of underground water;

xiii. Clearance of Village Panchayats and Pollution Control Board for Dumping Ground for Muck; and

xiv. Any other permits or clearances required under Applicable Laws.

xv. Consent to Establish (for any batching plant / asphalt plant / DG sets / crushers)

(ii) Applicable Permits, as required, relating to environmental protection & conservation and tree-felling, shall be procured by the Authority in accordance with the provisions of this Agreement.

Schedule – G

(See Clauses 7.1 and 19.2)

Annex-I

(See Clause 7.1)

Form of Bank Guarantee
[Performance Security/Additional Performance Security]

[……..]
Bangalore Development Authority (BDA)
WHEREAS:

(A) [name and address of contractor] (hereinafter called the "Contractor") has executed an agreement (hereinafter called the "Agreement") with the Bangalore Development Authority (BDA) and …..*address of the authority…..,* (hereinafter called the "Authority") for Construction of 3-Lane Bi-Directional Road Underpass on Bellary Road between Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU) Campus, Bengaluru on EPC Mode., subject to and in accordance with the provisions of the Agreement

(B) The Agreement requires the Contractor to furnish a Performance Security for due and faithful performance of its obligations, under and in accordance with the Agreement, during the {Construction Period/ Defects Liability Period and Maintenance Period} (as defined in the Agreement) in a sum of Rs….. cr. (Rupees ……crore) (the "**Guarantee Amount**").

(C) We, …….. through our branch at …….(the "**Bank**") have agreed to furnish this bank guarantee (*hereinafter called the "***Guarantee**") by way of Performance Security.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful performance of the Contractor's obligations during the {Construction Period/ Defects Liability Period and Maintenance Period} under and in accordance with the Agreement, and agrees and undertakes to pay to the Authority, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

2. A letter from the Authority, under the hand of an officer not below the rank of

[General Manager in Bangalore Development Authority (BDA), that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final and binding on the Bank, notwithstanding any differences between the Authority and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.

4. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.

5. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Agreement or to extend the time or period for the compliance with, fulfillment and/ or performance of all or any of the obligations of the Contractor contained in the Agreement or to postpone for any time, and from time to time, any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Agreement or for the fulfillment, compliance and/or performance of all or any of the obligations of the Contractor under the Agreement.

7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee Amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority under this Guarantee shall be forfeited and

the Bank shall be relieved from its liabilities hereunder.

8. The Guarantee shall cease to be in force and effect on ****[$]. Unless a demand or claim under this Guarantee is made in writing before expiry of the Guarantee, the Bank shall be discharged from its liabilities hereunder.

9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the Authority in writing and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.

10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorised to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.

11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the date specified in paragraph 8 above or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and sealed this ……. day of ……., 20……. at …….
SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:
(Signature)

(Name)

(Designation)

(Code Number)

(Address)

NOTES:

(i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.

(ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

[$] Insert date being 2 (two) years from the date of issuance of this Guarantee (in accordance with Clause 7.2 of the Agreement).

Annex – II

(Schedule - G)

(See Clause 19.2)

Form for Guarantee for Advance Payment

[……..]
Bangalore Development Authority (BDA)
WHEREAS:

(A) [name and address of contractor] (hereinafter called the "**Contractor**") has executed an agreement (hereinafter called the "**Agreement**") with the Bangalore Development Authority (BDA) and address of the authority], (hereinafter called the "**Authority**") for Construction of 3-Lane Bi-Directional Road Underpass on Bellary Road between Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU) Campus, Bengaluru on EPC Mode, subject to and in accordance with the provisions of the Agreement

(B) In accordance with Clause 19.2 of the Agreement, the Authority shall make to the Contractor an interest bearing *@Bank Rate + 3%* advance payment (herein after called "**Advance Payment**") equal to 10% (ten per cent) of the Contract Price; and that the Advance Payment shall be made in two installments subject to the Contractor furnishing an irrevocable and unconditional guarantee by a scheduled bank for an amount equivalent to 110% (one hundred and ten percent) of such installment to remain effective till the complete and full repayment of the installment of the Advance Payment as security for compliance with its obligations in accordance with the Agreement. The amount of {first/second} installment of the Advance Payment is Rs. ------ cr. (Rupees crore) and the amount of this Guarantee is Rs. ------- cr. (Rupees ------ crore) (the **"Guarantee Amount")**[$]**.**

(C) We, …….. through our branch at ……(the "**Bank"**) have agreed to furnish this bank guarantee (*hereinafter called the* **"Guarantee"**) for the Guarantee Amount.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful repayment on time of the aforesaid instalment of the Advance Payment under and in accordance with the Agreement, and agrees and undertakes to pay to the

[$] The Guarantee Amount should be equivalent to 110% of the value of the applicable instalment.

Authority, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

A letter from the Authority, under the hand of an officer not below the rank of [General Manager in the Bangalore Development Authority (BDA), that the Contractor has committed default in the due and faithful performance of all or any of its obligations for the repayment of the instalment of the Advance Payment under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final and binding on the Bank, notwithstanding any differences between the Authority and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

2. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.

3. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.

4. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Advance Payment or to extend the time or period of its repayment or to postpone for any time, and from time to time, any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

5. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Advance Payment.

6. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee Amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.

7. The Guarantee shall cease to be in force and effect on ****.[$] Unless a demand or claim under this Guarantee is made in writing on or before the aforesaid date, the Bank shall be discharged from its liabilities hereunder.

8. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the Authority in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.

9. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorised to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.

10. This Guarantee shall come into force with immediate effect and shall remain in force and effect up to the date specified in paragraph 8 above or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and sealed this ……. day of ……., 20……. at …….
SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:
(Signature)

(Name)

(Designation)

(Code Number)

(Address)

NOTES:

(i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.

[$] Insert a date being 90 (ninety) days after the end of one year from the date of payment of the Advance payment to the Contractor (in accordance with Clause 19.2 of the Agreement).

(ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

_____

SCHEDULE - H

See Clauses10.1 (iv) and 19.3

Contract Price Weightages

1.1 The Contract Price for this Agreement is Rs. ******

1.2 Proportions of the Contract Price for different stages of Construction of the Project Road shall be as specified below:

Item	Weightage in percentage to the Contract Price	Stage for Payment	Percentage weightage
1	**2**	**3**	**4**
I. Road works including culverts, widening and repair of culverts.	0.70%	**A- Widening and strengthening of existing road**	
		(1) Earthwork up to top of the embankment	[**]
		(2) Sub-Grade	
		(3) Sub-Base Course	[**]
		(4) Non-Bituminous Base Course	[**]
		(5) Bituminous Base Course	[**]
		(6) Wearing Coat	[**]
		(7) Widening and repair of culverts	[**]
		B.1- Reconstruction/ New realignment/ bypass (Flexible pavement)	
		(1) Earthwork up to top of the embankment	[**]
		(2) Sub-Grade	
		(3) Sub Base Course	[**]
		(4) Non-Bituminous Base Course*	[**]
		(5) Bituminous Base Course	[**]
		(6) Wearing Coat	[**]
		B.2- Reconstruction/ New realignment/ bypass (Rigid Pavement)	
		(1) Earthwork up to top of the embankment	[**]
		(2) Sub-Grade	
		(3) Sub Base Course	
		(4) Dry Lean Concrete(DLC) Course	[**]
		(5) Pavement Quality Control (PQC) Course	[**]
		(6) Wearing Coat	100%
		C.1- Reconstruction/ New service road (Flexible pavement)	
		(1) Earthwork up to top of the embankment	[**]
		(2) Sub-Grade	
		(3)Sub Base Course	[**]
		(4) Non-Bituminous Base Course*	[**]
		(5) Bituminous Base Course	[**]
		(6) Wearing Coat	[**]
		C.2- Reconstruction/ New Service road (Rigid Pavement)	
		(1) Earthwork up to top of the embankment	[**]
		(2) Sub-Grade	
		(3) Sub Base Course	[**]

		(4) Dry Lean Concrete(DLC) Course	[**]
		(5) Pavement Quality Control (PQC) Course	[**]
		D- Re-Construction and New culverts on existing road, realignments, bypasses :	
		Culverts (length < 6 m)	[**]
II. Minor Bridges/ Underpasses / Overpasses	1.29%	**A.1- Widening and Repair of Minor bridges (length > 6 m and < 60 m)**	
		Minor bridges	
		(1) **Foundation:** On completion of the foundation work of abutments and piers	[**]
		(2) **Sub-structure**: On completion of abutments and piers with abutment/ pier cap.	[**]
		(3) **Super-structure:** On completion of the super-structure in all respects including wearing coat, bearings, expansion joints, handrails, crash barriers, road signs and markings, tests on completion etc. complete in all respect.	[**]
		(4) **Approaches**: On completion of approaches including wing walls/ return walls, Retaining walls, stone pitching, protection works for floor, embankment slope, etc. complete in all respect and fit for use.	[**]
		A.2- New Minor bridges (length >6 and <60 m.)	
		(1) **Foundation:** On completion of the foundation work of abutments and piers	[**]
		(2) **Sub–structure**: On completion of abutments and piers with abutment/ pier cap.	[**]

		(3) **Super-structure:** On completion of the super-structure upto deck slab including bearings.	[**]
		(4) **Miscellaneous Works** : On completion of wearing coat, expansion joint, crash barrier, railings, protection works and any remaining work associated to bridge including tests on bridge.	[**]
		(5) **Approaches**: On completion of approaches including wing walls/ return walls, Retaining walls, stone pitching, protection works for floor, embankment slope etc. complete in all respect and fit for use.	[**]
		(6) **Guide Bunds and River Training Works:** On completion of Guide Bunds and river Training Works complete in all respects	[**]
		B.1- Widening and Repair of underpasses / overpasses	
		Underpasses/ Overpasses	[**]
		B.2- New underpasses/ overpasses	
		(1) Foundation: On completion of the foundation work of abutments and piers	12.93%
		(2) **Substructure** : On completion of abutments and piers with abutment/ pier cap.	16.29%

		(3) **Super-structure:** On completion of the super-structure upto deck slab including bearing.	13.66%
		(4) **Miscellaneous Works:** On completion of wearing coat, expansion joint, crash barrier, railings and any remaining work associated to bridge including tests on bridge	[**]
		(5) **Approaches**: On completion of approaches including Wing walls/ Return walls, Retaining walls/ Reinforced Earth walls, stone pitching, protection works complete in all respect and fit for use.	0.25%
		6)Box Pushing	56.87%

III. Tunnels, Major Bridge(length > 60 m.) works and ROB/RUB/ elevated sections/flyovers including viaducts, if any	87.75%	**A.1- Widening and repairs of Major Bridges**	
		(1) Foundation	[**]
		i) Pile Foundation	
		ii) Open Foundation	
		(2) Sub-structure	[**]
		(3) Super-structure (including bearings)	[**]
		(4) Wearing Coat including expansion joints	[**]
		(5) Miscellaneous Items like hand rails, crash barriers, road markings etc.)	[**]
		(6) Wing walls/return walls	[**]
		(7) Guide Bunds, River Training works etc.	[**]
		(8) Approaches (including Retaining walls, stone pitching and protection works for floor, embankment slope etc.)	[**]
		A.2- New Major Bridges	
		(1) Foundation	
		(i) Well Foundation	[**]
		(ii) Pile Foundation	[**]
		(iii) Open Foundation	[**]
		(2) Sub-structure	[**]
		(3) Super-structure (including bearings)	[**]
		(4) Wearing Coat including expansion joints	[**]
		(5) Miscellaneous Items (like handrails, crash barriers, road markings etc.)	[**]
		(6) Wing walls/return walls	[**]
		(7) Guide Bunds, River Training works etc.	[**]
		(8) Approaches (including Retaining walls, stone pitching and protection works for floor, embankment slope, etc.)	
		B.1- Widening and repair of **(a) ROB** **(b) RUB**	[**] [**]

		(1) Foundation	[**]
		i) Pile Foundation	
		ii) Open Foundation	
		(2) Sub-structure	[**]
		(3) Super-structure (including bearings)	[**]

		(4) Wearing Coat: (a) in case of ROB- wearing coat including expansion joints complete in all respects as specified and (b) in case of RUB- rigid pavement under RUB including drainage facility complete in all respects as specified.	[**]
		(5) Miscellaneous Items (like hand rails, crash barriers, road markings etc.)	[**]
		(6) Wing walls/return walls	[**]
		(7) Approaches (including Retaining walls, stone pitching and protection works)	[**]
		B.2- New ROB/RUB	
		(a)ROB	
		(b) RUB	
		(1) Foundation	[**]
		(i) Well Foundation	[**]
		(ii) Pile Foundation	[**]
		(iii) Open Foundation	[**]
		(2) Sub-structure	[**]
		(3) Super-structure (including bearings)	[**]
		(4) Wearing Coat: (a) in case of ROB- wearing coat including expansion joints complete in all respects as specified and (b) in case of RUB- rigid pavement under RUB including drainage facility complete in all respects as specified.	[**]
		(5) Miscellaneous Items like hand rails, crash barriers, road markings etc.)	[**]
		(6) Wing walls/return walls	[**]
		(7) Approaches (including Retaining walls/Reinforced Earth wall, stone pitching and protection works)	[**]
		C.1- Widening and repair of Elevated Section/Flyovers/ Grade Separators	
		(1) Foundation	[**]
		i) Pile Foundation	[**]
		ii) Open Foundation	[**]
		(2) Sub-structure	[**]
		(3) Super-structure (including bearings)	[**]
		(4) Wearing Coat including expansion joints	[**]
		(5) Miscellaneous Items like hand rails, crash barriers, road markings etc.)	[**]
		(6) Wing walls/return walls	[**]
		(7) Approaches (including Retaining walls/Reinforced Earth wall, stone pitching and protection works)	[**]
		C.2-New Elevated Section/Flyovers/ Grade Separators	
		(1) Foundation	[**]
		(i) Well Foundation	[**]
		(ii) Pile Foundation	[**]
		(iii) Open Foundation	[**]

		(2) Sub-structure	[**]
		(3) Super-structure (including bearings)	[**]
		(4) Wearing Coat including expansion joints	[**]
		(5) Miscellaneous Items like hand rails, crash barriers, road markings etc.)	[**]
		(6) Wing walls/return walls	[**]
		(7) Approaches (including Retaining walls/Reinforced Earth wall, stone pitching and protection works)	[**]
		Tunnel Works	
		Civil Works	
		Ramps	
		Excavation	2.97%
		Piling	2.07%
		Muck Disposal	1.08%
		Base Slab	3.33%
		Walls	2.82%
		Columns Steel Structure & Roofing	1.54%
		Backfilling	0.07%
		Crash Barrier	0.06%
		Cut & Cover	
		Excavation	20.92%
		Secant Piling	16.69%
		Muck Disposal	7.64%
		Base Slab	11.79%
		Walls	12.02%
		Top Slab	13.61%
		Backfilling	3.19%
		Crash Barrier	0.20%

IV. Other works	10.26%	(i) Toll Plaza	[**]
		(ii) Drains & Walkways	
		(a) Drain	0.64%
		(b) Walkway	0.72%
		(iii) Road signs, markings, km stones, safety devices etc.	0.93%
		(iv) Overhead gantry mounted signs	
		(v) Project facilities (a) Bus Bays (b) Truck lay-byes (c) Rest areas (d) others	[**]
		(vi) Road side plantation	[**]

		(vii) Protection works# other than approaches to	[**]

		the bridges, elevated sections/ flyovers/grade separators and ROBs/RUBs.	
		(a) Crash Barrier	[**]
		(b) Retaining Wall	[**]
		(c) Breast Wall	[**]
		(viii) Safety and traffic management during construction	[**]
		ix)Electrical and Mechanical Works	
		(i) Instrumentation & Monitoring	8.76%
		(ii) Electrical Works	16.35%
		(iii) Mechanical Works	34.48%
		(iv) Tunnel Ventilation	2.06%
		(v) Fire Fighting	9.48%
		(vi) Control Center	1.23%
		x) Miscellaneous Works	
		(i) Site Clearance	0.02%
		(ii) Existing Road restoration and Junction Improvement	21.12%
		(iii) Land Scaping	0.87%
		(iv) Artwork in Tunnel	3.34%

*Note- In case of CTB and AIL layer, this stage may be modified suitably to permit separate weightages for each of these layers.

#Note - For specific type of protection work detailed stages can be included

1.1 Procedure of estimating the value of work done

1.1.1 Tunnel works.

Procedure for estimating the value of road work done shall be as follows:

Table 1.3.1

Stage of Payment	**Percentage weightage**	**Payment Procedure**
A-Widening and strengthening of existing road (1) Earthwork up to top of the embankment	[**]	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length or 500m whichever is less
(2) Sub-Grade	[**]	
(3) Sub-Base Course	[**]	
(4) Non Bituminous Base Course*	[**]	
(5) Bituminous Base Course	[**]	

(6) Wearing Coat	[**]	
(7) Widening and repair of culverts	[**]	Cost of completed culverts shall be determined pro rata basis with respect to the total no. of culverts. The payment shall be made on the

Stage of Payment	**Percentage weightage**	**Payment Procedure**
		completion of atleast one culvert. 75% of the cost will be payable on completion of box/ abutments and slab/ pipe and head wall. Remaining 25% will become payable on completion of protection works including return/ wing walls and any other work associated with culverts.
B.1- Reconstruction/New realignment/bypass (Flexible pavement) (1) Earthwork up to top of the embankment	[**]	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in full length or 500 m length, whichever is less.
(2) Sub-Grade	[**]	
(3) Sub Base Course	[**]	
(4) Non-Bituminous Base Course*	[**]	
(5) Bituminous Base Course	[**]	
(6) Wearing Coat	[**]	
B.2- Reconstruction/New realignment/bypass (Rigid pavement) (1) Earthwork up to top of the embankment	[**]	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in full length or 500 m length, whichever is less.
(2) Sub-Grade	[**]	
(3) Sub Base Course	[**]	
(4) Dry Lean Concrete (DLC) Course	[**]	
(5) Pavement Quality Control (PQC) Course	[**]	
(6) Wearing Coat	100%	
C.1- Reconstruction/ New service road (Flexible pavement) (1) Earthwork up to top of the embankment	[**]	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in full length or 500 m length, whichever is less.
(2) Sub-Grade	[**]	
(3) Subbase Course	[**]	
(4) Non-Bituminous Base Course*	[**]	
(5) Bituminous Base Course	[**]	

(6) Wearing Coat		
C.2- Reconstruction/ New service road (Rigid pavement) (1) Earthwork up to top of	[**]	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in full length or 500 m

Stage of Payment	**Percentage weightage**	**Payment Procedure**
the embankment		length, whichever is less.
(2) Sub-Grade	[**]	
(3) Subbase Course	[**]	
(4) Dry Lean Concrete (DLC) Course	[**]	
(5) Pavement Quality Control (PQC) Course	[**]	
D- Re-Construction and New culverts on existing roads, realignments, bypasses: (1) Culverts (length < 6m)	[**]	Cost of each culvert shall be determined on pro rata basis with respect to the total number of culverts. Payment shall be made on the completion of at least one culvert. 75% of the cost will be payable on completion of box/ abutments and slab/ pipe and head wall. Remaining 25% will become payable on completion of protection works including return/ wing walls and any other work associated with culverts.

*Note- In case of CTB and AIL layer, this stage may be modified suitably to permit separate weightages for each of these layers.

@. For example, if the total length of bituminous work to be done is 100 km, the cost per km of bituminous work shall be determined as follows:

Cost per km = P x weightage for road work x weightage for bituminous work x (1/L)

Where P= Contract Price L =

Total length in km

Similarly, the rates per km for other stages shall be worked out accordingly.

Note: The length affected due to law-and-order problems or litigation during execution due to which the Contractor is unable to execute the work, may be deducted from the total project length for payment purposes. The total length calculated here is only for payment purposes and will not affect and referred in other clauses of the Contract Agreement.

1.1.2 Minor Bridges and Underpasses/Overpasses.

Procedure for estimating the value of Minor bridge and Underpasses/Overpasses shall be as stated in table 1.3.2:

Table 1.3.2

Stage of Payment	Weightage	Payment Procedure
1	2	3
A.1-Widening and repair of minor bridges (length > 6m and < 60m)	**[**]**	Cost of each minor bridge shall be determined on pro rata basis with respect to the total linear length (m) of the minor bridges.
(i) **Foundation:** On completion of the foundation work of abutments and piers	**[**]**	(i) **Foundation:** Payment against foundation shall be made on pro-rata basis on completion of a stage i.e completion of atleast two foundations of each bridge. In case where load testing is specified for foundation, the trigger of first payment shall include load testing also.
(ii) Sub – structure:	**[**]**	**(ii) Sub - structure** – Payment shall be made on pro-rata basis on completion of stage i.e. completion of atleast one sub-structure upto abutment/ pier cap level of each bridge.
(iii) **Super-structure:** On completion of the super-structure in all respects including wearing coat, bearings, expansion joints, hand rails, crash barriers, road signs & markings, tests on completion etc. complete in all respect.	**[**]**	(iii) **Super-structure:** Payment shall be made on pro-rata basis on completion of a stage i.e., completion of super-structure of at least one span in all respects as specified in the column of "Stage of Payment" in this sub-clause.
(iv) **Approaches**: On completion of approaches including Retaining walls, stone pitching, protection works for floor, embankment slope etc. complete in all respect and fit for use.	**[**]**	(iv) **Approaches:** Payment shall be made on pro-rata basis on completion of a stage i.e. completion of approaches including wing walls/ return walls, retaining walls, stone pitching in all respect as specified in the column of “Stage of Payment” in this sub- clause for each bridge.
A.2- New minor bridges (i) **Foundation:** On completion of the foundation work of abutments and piers.	**[**]**	Cost of each minor bridge shall be determined on pro rata basis with respect to the total linear length (m) of the minor bridges. (i) **Foundation:** Payment against foundation shall be made on pro-rata basis on completion of a stage completion of atleast two foundations of each bridge. In case where load testing is specified for foundation, the trigger of first payment shall include load testing also.

Stage of Payment	**Weightage**	**Payment Procedure**
1	**2**	**3**
(ii) Sub – structure:	**[**]**	(ii) Sub - structure – Payment shall be made on pro-rata basis on completion of stage i.e. completion of atleast one sub-structure upto abutment/ pier cap level of each bridge.
(iii) **Super-structure:** On completion of the super-structure upto deck slab including bearings.	**[**]**	(iii) **Super-structure:** Payment shall be made on pro-rata basis on completion of a stage i.e., completion of super-structure of at least one span upto deck slab including bearing as specified in the column of "Stage of Payment" in this sub- clause. If pre-cast girders/ segments are used, interim payments shall be made at 75% of the cost of that element, as derived from MoRTH Data Book, applicable SOR of State PWD on Base Date with tender discount/premium applied thereon.
(iv) **Miscellaneous Works:**	**[**]**	(iv) **Miscellaneous Works**: Payment shall be made on pro-rata basis on completion of a stage i.e. completion of wearing coat, expansion joint, crash barrier, railing, protection works, drainage and any other remaining work associated to bridge including tests on bridge for each bridge
v) **Approaches**: On completion of approaches including Retaining walls, stone pitching, protection works for floor, embankment slope etc. complete in all respect and fit for use.	**[**]**	(v) **Approaches:** Payment shall be made on pro-rata basis on completion of a stage i.e. completion of approaches including wing walls/ return walls, retaining walls, stone pitching in all respect as specified in the column of "Stage of Payment" in this sub- clause for each bridge.
(vi) **Guide Bunds and River Training Works:** On completion of Guide Bunds and river Training Works complete in all respects	**[**]**	(vi) **Guide Bunds and River Training Works:** Payment shall be made on pro-rata basis on completion of a stage i.e. completion of Guide Bunds and River training Works in all respects as specified for each bridge.
B.1-Widening and repair of underpasses / overpasses	**[**]**	Cost of each underpass/overpass shall be determined on pro rata basis with respect to the total linear length of the underpasses/overpasses. Payment shall be made on the completion of widening & repair works of a underpass/overpass.
B.2- New Underpasses/	**[**]**	Cost of each Underpass/Overpass shall be

Stage of Payment	Weightage	Payment Procedure
1	2	3
~~**Overpasses:**~~ **(i) Foundation** On completion of the foundation work including foundations, of abutments and piers	12.93%	determined on pro rata basis with respect to the total linear length (m) of the Underpasses/Overpasses. (i) **Foundation:** Payment against foundation shall be made on pro-rata basis on completion of a stage i.e. completion of foundation(s) of each underpass/overpass. In case where load testing is specified for foundation, the trigger of first payment shall include load testing also.
(ii) Sub-structure :	16.29%	(ii) Sub-structure: Payment shall be made on pro-rata basis on completion of stage i.e. completion of atleast one sub-structure upto abutment/ pier cap level of each bridge.
(iii) **Super-structure:** On completion of the super-structure upto deck slab,	13.66%	(iii) **Super-structure:** Payment shall be made on pro-rata basis on completion of a stage 'i.e. completion of super-structure of at least one span upto deck slab including bearing as specified in the column of "Stage of Payment" in this sub- clause: If pre-cast girders/ segments are used, interim payments shall be made at 75% of the cost of that element, as derived from MoRTH Data Book, applicable SOR of State PWD on Base Date with tender discount/premium applied thereon.
(iv) Miscellaneous Works:	**[**]**	(iv) Miscellaneous Works: Payment shall be made on pro-rata basis on completion of a stage i.e. completion of wearing coat, expansion joint, crash barrier, railing, protection works and any other remaining work associated to bridge including tests on bridge for each bridge.
v) **Approaches**: On completion of approaches including wing wall/ return wall, Retaining walls/ Reinforced Earth walls, stone pitching, protection work s complete in all respect and fit for use.	**0.25%**	(v) **Approaches:** Payment shall be made on pro-rata basis on completion of a stage i.e. completion of approaches including wing wall/ return wall, retaining walls, Reinforced Earth walls, stone pitching, protection works complete in all respect for each bridge.
vi) Box Pushing	**56.87%**	Payment shall be made on pro-rata basis on completion in all respect.

1.1.3 Major Bridge works, ROB/RUB and Structures.

Procedure for estimating the value of Major Bridge works, ROB/RUB and Structures shall be as stated in table 1.3.3:

Table 1.3.3

Stage of Payment	Weightage	Payment Procedure
1	2	3
A.1- Widening and repairs of Major Bridges (1) Foundation	**[**]**	Cost of each Major Bridge shall be determined on pro rata basis with respect to the total linear length (m) of the Major Bridges. (1) **Foundation:** Payment against foundation shall be made on pro-rata basis on completion of a stage i.e. completion of atleast one foundation of each of the major Bridge as specified hereinunder.
(i) Pile Foundation (a) Piling – On completion of pile upto bottom of pile cap (b) Pile Cap : On completion of pile cap		(i) Pile Foundation (a) Piling : Payment of 70% shall be made on completion of piling upto bottom of pile cap for each pile on prorate basis. (b) Pile Cap : Payment of 30% on pro-rata basis shall be made on completion of pile cap. In case where load testing is required for foundation, the trigger of first payment shall include load testing also where specified.
(ii) Open Foundation		(ii) Open Foundation: Payment shall be made on completion of a stage i.e. on completion of atleast one foundation.
(2) Sub-structure	**[**]**	**(2) Sub-Structure:**. Payment against Sub-structure shall be made on pro- rata basis on completion of a stage i.e. completion of atleast one sub-structure of abutments/piers upto abutment/pier cap level of each of

Stage of Payment	**Weightage**	**Payment Procedure**
1	**2**	**3**
		the major bridge.
(3) Super-structure (including bearings)	**[**]**	(3) **Super-structure:** Payment shall be made on prorata basis on completion of a stage i.e. completion of superstructure upto deck slab including bearings of at least one span as specified here in under : If pre-cast RCC/PSC/Steel girders/ segments are used, interim payments shall be made at 75% of the cost of that element, as derived from MoRTH Data Book, applicable SOR of State PWD on Base Date with tender discount/premium applied thereon.
(4) Wearing Coat including expansion joints	**[**]**	**(4) Wearing Coat:** Payment shall be made on completion of wearing coat including expansion joints complete in all respects as specified for each major bridge.
(5) Miscellaneous Items like hand rails, crash barriers, road markings etc.	**[**]**	(5) **Miscellaneous:** Payments shall be made on completion of all miscellaneous works like hand rails, crash barriers, road markings etc. complete in all respects as specified for each major bridge.
(6) Wing walls/return walls	**[**]**	(6) **Wing walls/return walls:** Payments shall be made on completion of all wing walls/return walls complete in all respects as specified for each major bridge.
(7) Guide Bunds, River Training works etc.	**[**]**	(7) **Guide Bunds, River Training works:** Payments shall be made on completion of all guide bunds/river training works etc. complete in all respects as specified for each major bridge.
(8) Approaches (including Retaining walls, stone pitching and protection works)	**[**]**	**(8) Approaches**: Payments shall be made on completion of both approaches including stone pitching, protection works, etc. complete in

Stage of Payment	Weightage	Payment Procedure
1	2	3
		all respects as specified for each major bridge.
A.2- New Major Bridges (1) Foundation	**[**]**	Cost of each Major Bridge shall be determined on pro rata basis with respect to the total linear length (m) of the Major Bridge. (1) **Foundation:** Payment against foundation shall be made on pro-rata basis on completion of a stage i.e. completion of atleast one foundation of each of the major Bridge as specified here in under:
(i) Well Foundation (a) On completion of Cutting Edge + Well Curb (b) Wellsteining : On completion of well steining upto bottom of well cap. (c) On completion of bottom plug + top plug (if provisioned as per design) + well cap		(i) Well Foundation (a) Cutting Edge + Well Curb: Payment of 10% shall be made on completion of a stage i.e. completion of cutting edge + well curb. (b) Well steining : Payment of 65% shall be made on completion of well steining upto bottom of well cap. The payment stage shall be further sub-divided on pro-rata basis i.e. (i) on completion upto 10 m and (ii) on completion of each subsequent 5 m or part thereof. (c) Bottom plug + top plug (if provisioned as per design) + well cap: Payment of 25% shall be made on completion of a stage i.e. completion of bottom plug, back fill, top plug and well cap.
(ii) Pile Foundation (a) Piling – On completion of pile upto bottom of pile cap (b) Pile Cap : On completion of pile cap		(ii) Pile Foundation (a) Piling : Payment of 70% shall be made on completion of piling upto bottom of pile cap for each pile on prorota basis. (b) Pile Cap : Payment of 30% shall be made on completion of pile cap. In case where load testing is required for foundation, the trigger of first payment shall include load testing

Stage of Payment	Weightage	Payment Procedure
1	2	3
		also where specified.
(iii) Open Foundation		(iii) Open Foundation: Payment shall be made on completion of a stage i.e. on completion of atleast one foundation.
(2) Sub-structure	**[**]**	**(ii) Sub-Structure:**. Payment against Sub-structure shall be made on pro- rata basis on completion of a stage i.e. completion of atleast one sub-structure of abutments/piers upto abutment/pier cap level of each of the major bridge.
(3) Super-structure (including bearings)	**[**]**	(3) **Super-structure:** Payment shall be made on prorata basis on completion of a stage i.e. completion of superstructure upto deck slab including bearings of at least one span as specified here in under: If pre-cast girders/ segments are used, interim payments shall be made at 75% of the cost of that element, as derived from MoRTH Data Book, applicable SOR of State PWD on Base Date with tender discount/premium applied thereon. (For cable stayed bridge and suspension cable bridge, detailed payment stage may be included on case to case basis)
(4) Wearing Coat including expansion joints	**[**]**	**(4) Wearing Coat:** Payment shall be made on completion of wearing coat including expansion joints complete in all respects as specified for each major bridge.
(5) Miscellaneous Items like hand rails, crash barriers, road markings etc.	**[**]**	(5) **Miscellaneous:** Payments shall be made on completion of all miscellaneous works like hand rails, crash barriers, road markings etc. complete in all respects as specified for each major bridge.
(6) Wing walls/return walls	**[**]**	(6) **Wing walls/return walls:** Payments shall be made on completion of all wing walls/return walls complete in all respects as specified for each

		major bridge.
(7) Guide Bunds, River Training works etc.	**[**]**	(7) **Guide Bunds, River Training works:** Payments shall be made on completion of all guide bunds/river training works etc. complete in all respects as specified for each major bridge.
(8) Approaches (including Retaining walls, stone pitching and protection works for floor, embankment slope etc.)	**[**]**	**(8) Approaches**: Payments shall be made on completion of both approaches including stone pitching, protection works, etc. complete in all respects as specified for each major bridge.
B.1 -Widening and repairs of **(a) ROB** **(b) RUB** (1) Foundation	**[**]**	Cost of each ROB/RUB shall be determined on pro rata basis with respect to the total linear length (m) of the ROBs/RUBs. (1) **Foundation:** Payment against foundation shall be made on pro-rata basis on completion of a stage i.e. completion of atleast one foundation of each of the ROB/RUB as specified here in under.
(i) Pile Foundation Piling – On completion of pile upto bottom of pile cap (b) Pile Cap : On completion of pile cap (ii) Open Foundation		(i) Pile Foundation (a) Piling : Payment of 70% shall be made on completion of piling upto bottom of pile cap for each pile on prorata basis. (b) Pile Cap : Payment of 30% on pro-rata basis shall be made on completion of pile cap. In case where load testing is required for foundation, the trigger of first payment shall include load testing also where specified.
		(ii) Open Foundation: Payment shall

Stage of Payment	Weightage	Payment Procedure
1	**2**	**3**
		be made on completion of a stage i.e. on completion of atleast one foundation.
(2) Sub-structure	**[**]**	**(2) Sub-Structure:**. Payment against Sub-structure shall be made on pro-rata basis on completion of a stage i.e. completion of atleast one sub- structure of abutments/piers upto abutment/pier cap level of each of the ROB/RUB.

(3) Super-structure (including bearings)	**[**]**	(3) **Super-structure:** Payment shall be made on pro-rata basis on completion of a stage i.e. completion of superstructure upto deck slab including bearings of at least one span as specified here in under : If pre-cast girders/ segments are used, interim payments shall be made at 75% of the cost of that element, as derived from MoRTH Data Book, applicable SOR of State PWD on Base Date with tender discount/premium applied thereon.
(4) Wearing Coat including expansion joints in case of ROB. In case of RUB, rigid pavement under RUB including drainage facility as specified.	**[**]**	**(4) Wearing Coat:** Payment shall be made on completion of (a) in case of ROB- wearing coat including expansion joints complete in all respects as specified for each of the ROB and (b) in case of RUB- rigid pavement under RUB including drainage facility complete in all respects as specified for each of the RUB.
(5) Miscellaneous Items like hand rails, crash barriers, road markings etc.	**[**]**	(5) **Miscellaneous:** Payments shall be made on completion of all miscellaneous works like hand rails, crash barriers, road markings etc. complete in all respects as specified for each of the ROB/ RUB.
(6) Wing walls/return walls	**[**]**	(6) **Wing walls/return walls:**

Stage of Payment	**Weightage**	**Payment Procedure**
1	**2**	**3**
		Payments shall be made on completion of all wing walls/return walls complete in all respects as specified for each of the ROB/ RUB.
(7) Approaches (including Retaining walls, stone pitching and protection works)	**[**]**	**(7) Approaches**: Payments shall be made on completion of both approaches including stone pitching, protection works, etc. complete in all respects as specified for each of the ROB/ RUB.
B.2- New **(a) ROB** **(b) RUB** (1) Foundation	**[**]**	Cost of each ROB/RUB shall be determined on pro rata basis with respect to the total linear length (m) of the ROBs/RUBs. (1) **Foundation:** Payment against foundation shall be made on pro-rata basis on completion of a stage i.e. completion of atleast one foundation of each of the ROB/RUB as specified here in under:

(i) Well Foundation (a) On completion of Cutting Edge + Well Curb (b) Wellsteining : On completion of well steining upto bottom of well cap. (c) On completion of bottom plug + top plug (if provisioned as per design) + well cap	**[**]**	(i) Well Foundation (a) Cutting Edge + Well Curb: Payment of 10% shall be made on completion of a stage i.e. completion of cutting edge + well curb. (b) Well steining : Payment of 65% shall be made on completion of well steining upto bottom of well cap. The payment stage shall be further sub-divided on pro-rata basis i.e. (i) on completion upto 10 m and (ii) on completion of each subsequent 5 m or part thereof. (c) Bottom plug + top plug (if provisioned as per design) + well cap: Payment of 25% shall be made on completion of a stage i.e. completion of bottom plug, back fill, top plug and well cap.
(ii) Pile Foundation (a) Piling – On completion of pile upto bottom of pile	**[**]**	(ii) Pile Foundation (a) Piling : Payment of 70% shall be made on completion of piling upto

Stage of Payment	**Weightage**	**Payment Procedure**
1	**2**	**3**
cap (b) Pile Cap : On completion of pile cap	**[**]**	bottom of pile cap for each pile on prorota basis. (b) Pile Cap : Payment of 30% shall be made on completion of pile cap. In case where load testing is required for foundation, the trigger of first payment shall include load testing also where specified.
(iii) Open Foundation		(iii) Open Foundation: Payment shall be made on completion of a stage i.e. on completion of atleast one foundation.
2) Sub-structure	**[**]**	**(2) Sub-Structure:** Payment against Sub-structure shall be made on pro- rata basis on completion of a stage i.e. completion of atleast one sub-structure of abutments/piers upto abutment/pier cap level of each of the ROB/RUB.

(3) Super-structure (including bearings)	**[**]**	(3) **Super-structure:** Payment shall be made on prorata basis on completion of a stage i.e. completion of superstructure upto deck slab including bearings of at least one span as specified here in under : If pre-cast girders/ segments are used, interim payments shall be made at 75% of the cost of that element, as derived from MoRTH Data Book. Applicable SOR of State PWD on Base Date with tender discount/premium applied thereon.
(4) Wearing Coat including expansion joints in case of ROB. In case of RUB, rigid pavement under RUB including drainage facility as specified.	**[**]**	**(4) Wearing Coat:** Payment shall be made on completion of (a) in case of ROB- wearing coat including expansion joints complete in all respects as specified for each of the ROB and (b) in case of RUB- rigid pavement under RUB including drainage facility complete in all respects as specified for each of the RUB.

Stage of Payment	**Weightage**	**Payment Procedure**
1	**2**	**3**
(5) Miscellaneous Items like hand rails, crash barriers, road markings etc.	**[**]**	(5) **Miscellaneous:** Payments shall be made on completion of all miscellaneous works like hand rails, crash barriers, road markings etc. complete in all respects as specified for each of the ROB/RUB.
(6) Wing walls/return walls	**[**]**	(6) **Wing walls/return walls:** Payments shall be made on completion of all wing walls/return walls complete in all respects as specified for each of the ROB/RUB.
(7) Approaches (including Retaining walls/Reinforced Earth wall, stone pitching and protection works)	**[**]**	**(7) Approaches**: Payments shall be made on completion of both approaches of each ROB including stone pitching, protection works, etc. complete in all respects as specified here in under : If reinforced soil wall is used with facia panel/blocks, interim payment shall be made @75% of the Cost of that element as derived from MoRTH data Book. Applicable SOR of State PWD on Base Date with tender discount/premium

		applied thereon.
C.1- Widening and repairs of Elevated Section/Flyovers/ Grade Separators (i) Foundation		Cost of each structure shall be determined on pro rata basis with respect to the total linear length (m) of the structures. (1) Foundation : Payment against foundation shall be made on pro-rata basis on completion of a stage i.e. completion of atleast one foundation of each of the structure as specified here in under :
(i) Pile Foundation (a) Piling – On completion of pile upto bottom of pile cap (b) Pile Cap : On		(i) Pile Foundation (a) Piling : Payment of 70% shall be made on completion of piling upto bottom of pile cap for each pile on prorate basis. (b) Pile Cap : Payment of 30% on pro-

Stage of Payment	**Weightage**	**Payment Procedure**
1	**2**	**3**
Completion of pile cap		rata basis shall be made on completion of pile cap. In case where load testing is required for foundation, the trigger of first payment shall include load testing also where specified.
(ii) Open Foundation		(ii) Open Foundation: Payment shall be made on completion of a stage i.e. on completion of atleast one foundation.
(2) Sub-structure	**[**]**	**(2) Sub-Structure:** Payment against Sub-structure shall be made on pro- rata basis on completion of a stage i.e. completion of atleast one sub-structure of abutments/piers upto abutment/pier cap level of each of the structure.

(3) Super-structure (including bearings)	**[**]**	(3) **Super-structure:** Payment shall be made on pro-rata basis on completion of a stage i.e. completion of super- structure upto deck slab including bearings of at least one span as specified here in under : If pre-cast girders/ segments are used, interim payments shall be made at 75% of the cost of that element, as derived from MoRTH Data Book, applicable SOR of State PWD on Base Date with tender discount/premium applied thereon.
(4) Wearing Coat including expansion joints	**[**]**	**(4) Wearing Coat:** Payment shall be made on completion of wearing coat including expansion joints complete in all respects as specified for each of the structure.
(5) Miscellaneous Items like hand rails, crash barriers, road markings etc.	**[**]**	(5) **Miscellaneous:** Payments shall be made on completion of all miscellaneous works like hand rails, crash barriers, road markings etc. complete in all respects as specified for each of the structure.

Stage of Payment	**Weightage**	**Payment Procedure**
1	**2**	**3**
(6) Wing walls/return walls	**[**]**	(6) **Wing walls/return walls:** Payments shall be made on completion of all wing walls/return walls complete in all respects as specified for each of the structure.
(7) Approaches (including Retaining walls/Reinforced Earth wall, stone pitching and protection works)	**[**]**	**(7) Approaches**: Payments shall be made on completion of both approaches including stone pitching, protection works, etc. complete in all respects of each structure.
C.2 -New Elevated Section/Flyovers/ Grade Separators		Cost of each structure shall be determined on pro rata basis with respect to the total linear length (m) of the structures.
(1) Foundation	**[**]**	(1) **Foundation:** Payment against foundation shall be made on pro-rata basis on completion of a stage i.e. completion of atleast one foundation of each of the structure as specified here in under :

(i) Well Foundation (a) On completion of Cutting Edge + Well Curb (b) Wellsteining : On completion of well steining upto bottom of well cap. (c) On completion of bottom plug + top plug (if provisioned as per design) + well cap		(i) Well Foundation (a) Cutting Edge + Well Curb: Payment of 10% shall be made on completion of a stage i.e. completion of cutting edge + well curb. (b) Well steining : Payment of 65% shall be made on completion of well steining upto bottom of well cap. The payment stage shall be further sub-divided on pro-rata basis i.e. (i) on completion upto 10 m and (ii) on completion of each subsequent 5 m or part thereof. (c) Bottom plug + top plug (if provisioned as per design) + well cap: Payment of 25% shall be made on completion of a stage i.e. completion of bottom plug, back fill, top plug and well cap.
(ii) Pile Foundation		(ii) Pile Foundation

(a) Piling – On completion of pile upto bottom of pile cap (b) Pile Cap : On completion of pile cap		(a) Piling : Payment of 70% shall be made on completion of piling upto bottom of pile cap for each pile on pro-rata basis. (b) Pile Cap : Payment of 30% shall be made on completion of pile cap. In case where load testing is required for foundation, the trigger of first payment shall include load testing also where specified.
(iii) Open Foundation		(iii) Open Foundation: Payment shall be made on completion of a stage i.e. on completion of atleast one foundation.
(2) Sub-structure	**[**]**	**(2) Sub-Structure:**. Payment against Sub- structure shall be made on pro-rata basis on completion of a stage i.e. completion of atleast one sub-structure of abutments/piers upto abutment/pier cap level of each of the structure.

(3) Super-structure (including bearings)	**[**]**	(3) **Super-structure:** Payment shall be made on pro-rata basis on completion of a stage i.e. completion of super- structure upto deck slab including bearings of at least one span as specified here in under: If pre-cast girders/ segments are used, interim payments shall be made at 75% of the cost of that element, as derived from MoRTH Data Book, applicable SOR of State PWD on Base Date with tender discount/premium applied thereon.
(4) Wearing Coat including expansion joints	**[**]**	**(4) Wearing Coat:** Payment shall be made on completion of wearing coat including expansion joints complete in all respects as specified for each of the structure.

Stage of Payment	**Weightage**	**Payment Procedure**
1	**2**	**3**
(5) Miscellaneous Items like hand rails, crash barriers, road markings etc.	**[**]**	(5) **Miscellaneous:** Payments shall be made on completion of all miscellaneous works like handrails, crash barriers, road markings etc. complete in all respects as specified for each of the structure.
(6) Wing walls/return walls	**[**]**	(6) **Wing walls/return walls:** Payments shall be made on completion of all wing walls/return walls complete in all respects as specified for each of the structure.

(7) Approaches (including Retaining walls/Reinforced Earth wall, stone pitching and protection works)	**[**]**	**(7) Approaches**: Payments shall be made on completion of both approaches including stone pitching, protection works, etc. complete in all respects as specified here in under : If reinforced soil wall is used with facia panel/blocks, interim payment shall be made @75% of the Cost of that element as derived from MoRTH data Book. Applicable SOR of State PWD on Base Date with tender discount/premium applied thereon.
Tunnel Works		
Civil Works		
Ramps		
Excavation	2.97%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length.
Piling	2.07%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length.
Muck Disposal	1.08%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis.
Base Slab	3.33%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length.
Walls	2.82%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length
Columns Steel Structure & Roofing	1.54%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length
Backfilling	0.07%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length

Crash Barrier	0.06%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length
Cut & Cover		
Excavation	20.92%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length.
Secant Piling	16.69%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length.
Muck Disposal	7.64%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis.
Base Slab	11.79%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length
Walls	12.02%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length
Top Slab	13.61%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length
Backfilling	3.19%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length
Crash Barrier	0.20%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than 10 (ten) percent of the total length

1.1.4 Other works.

Procedure for estimating the value of other works done shall be as stated in table 1.3.4.

Table 1.3.4

Stage of Payment	**Weightage**	**Payment Procedure**
1	**2**	**3**
(i) Toll plaza	[**]	Unit of measurement is each completed toll plaza. Payment for each toll plaza shall be made on pro rata basis with respect to the total of all toll plazas as specified here in under:

Stage of Payment	**Weightage**	**Payment Procedure**
1	**2**	**3**
(a) DLC(LHS)		(a) DLC (LHS) : Payment of 12.5% on pro-rata basis shall be made on completion of a stage i.e. completion of DLC on LHS.
(b) DLC (RHS)	[**]	(b) DLC (RHS) : Payment of 12.5% on pro-rata basis shall be made on completion of a stage i.e. completion of DLC on LHS.
(c) PQC(LHS)	[**]	(c) PQC(LHS): Payment of 25% on pro-rata basis shall be made on completion of a stage i.e. completion of PQC on LHS.
(d) PQC(RHS)	[**]	(d) PQC(RHS): Payment of 25% on pro-rata basis shall be made on completion of a stage i.e. completion of PQC on RHS.
(e) Admin Building	[**]	(e) Admin Building: Payment of 10% on pro-rata basis shall be made on completion of a stage i.e. completion of Admin Building and miscellaneous works.
(f) Toll Booth, canopy, safety items and all other associated works	[**]	(f) Toll Booth, canopy, safety items and all other associated works: Payment of 15% on pro-rata basis shall be made on completion of a stage i.e. completion of Toll Booth, canopy, safety items and all other associated works.

(ii) Road side drains	[**]	
(a) Drains	0.64%	a) Drains: Unit of measurement is linear length in metre . Payment shall be made on pro rata basis on completion of a stage in a length of not less than 100 m on one side.
(b) Walkway	0.72%	(b) Walkway: Unit of measurement is linear length in metre. Payment shall be made on pro rata basis on completion of a stage in a length of not less than 100 m on one side.

(iii) Road signs, markings, km stones, safety devices, …	0.93%	Unit of measurement is linear length in km. Payment shall be made on pro rata basis on completion of a stage in a length of not less than one Km on both sides.
(iv) **Overhead gantry mounted signs**	[**]	Unit of measurement is each number. Payment shall be made on pro-rata basis on completion of each overhead gantry mounted sign
(v) Project Facilities (a) Bus bays (b) Truck lay-byes (c) Rest areas (d) others	 [**] [**] [**] [**]	Unit of measurement is each number. Payment shall be made on pro rata basis for completed facilities.
(vi) Roadside plantation	[**]	Unit of measurement is linear length in Km. Payment shall be made on pro rata basis on completion of one Km.
(vii) Protection works other than approaches to the bridges, elevated sections/ flyovers/grade separators and ROBs/ RUBs (a) Crash- Barrier (b) Retaining wall (c) Breast wall	 [**] [**] [**]	Unit of measurement is linear length. Payment against items (a), (b) & (c) shall be made on pro rata basis on completion of a stage in a length of not less than 10% (ten per cent) of the total length and 100 m whichever is less.

(viii) Safety and traffic management during construction	**[**]**	Payment shall be made on prorata basis every six months.
ix)Electrical and Mechanical Works		Payment shall be made on pro rata basis for completed facilities.
(i) Instrumentation & Monitoring	8.76%	
(ii) Electrical Works	16.35%	Payment shall be made on pro-rata basis.
(iii) Mechanical Works	34.48%	Payment shall be made on pro-rata basis.
(iv) Tunnel Ventilation	2.06%	Payment shall be made on pro-rata basis.
(v) Fire Fighting	9.48%	Payment shall be made on completed Facilities.
(vi) Control Center	1.23%	Payment shall be made on completed Facilities.
X) Miscellaneous Works		
(i) Site Clearance	0.02%	Payment shall be made on pro-rata basis on completed Facilities.
(ii) Existing Road restoration and Junction Improvement	21.12%	Payment shall be made on pro-rata basis on completed Facilities.
(iii) Land Scaping	0.87%	Payment shall be made on pro-rata basis on completed Facilities.
(iv) Artwork in Tunnel	3.34%	Payment shall be made on pro-rata basis on completed Facilities.

Note: (1) In case of innovative Major Bridge Projects like cable suspension/cable stayed and exceptionally long span bridges, the schedule may be modified as per site requirements before bidding with due approval of Competent Authority.

(2) The Schedule for exclusive Tunnel Projects may be prepared as per site requirements before bidding with due approval of Competent Authority.

(3) (a) In order to maintain cash flow in the project, the Authority shall also make interim monthly payments to the Contractor for the work done during the month for which the corresponding stage, as mentioned in Schedule-H, has not been achieved. Such work shall be measured, in a length, number or area as specified in corresponding stage of Schedule-H and valued in accordance with the proportion of the weightage of Contract Price assigned to that stage in Schedule-H. '90% of value of such work shall be paid as an 'Interim Monthly Payment' under clause 19.3 (i) of Contract Agreement.

(b) For Pre cast/ pre-fabricated elements to be used in permanent works, interim payments to be made @ 75% of cost of that element (to be derived from MoRT&H data book) as per schedule H.

(C) Upon completion of the defined 'stage', a reconciliation of the interim payments shall be carried out, and any balance amount shall be paid. For the avoidance of doubt, it is clarified that the interim monthly payments are made solely to maintain cash flow in the project. In the event of termination of the project, under Clause23.1, 23.2 or 23.3, as the case may be, such interim payments shall be dealt with as per Clause 23.5 (i) (b) of the Contract Agreement.

(See Clause 10.2 (iv))

Drawings

1. Drawings

In compliance of the obligations set forth in Clause 10.2 of this Agreement, the Contractor shall furnish to the Authority's Engineer, free of cost, all Drawings listed in Annex-I of this Schedule-I.

2. Additional Drawings

If the Authority's Engineer determines that for discharging its duties and functions under this Agreement, it requires any drawings other than those listed in Annex-I, it may by notice require the Contractor to prepare and furnish such drawings forthwith. Upon receiving a requisition to this effect, the Contractor shall promptly prepare and furnish such drawings to the Authority's Engineer, as if such drawings formed part of Annex-I of this Schedule-I.

Annex – I

(Schedule - I)

List of Drawings

[**Note**: The Authority shall describe in this Annex-I, all the Drawings that the Contractor is required to furnish under Clause 10.2.]

A. GENERAL ARRANGEMENT (GA) DRAWINGS

1. Key Plan & Location Plan of Project
2. Overall Alignment Plan of Tunnel + Ramp + RUB
3. General Arrangement Drawings (GAD): Entire Corridor
4. GAD – Urban Road Tunnel Section (Chainage-wise)
5. GAD – Open-to-Sky Entry Ramp
6. GAD – Open-to-Sky Exit Ramp
7. GAD – Road Under Bridge (RUB) by Box Pushing Method
8. Longitudinal Section along Alignment (including RUB portion)
9. Typical Cross-Sections – Tunnel, Ramps, RUB

B. CUT-AND-COVER TUNNEL DRAWINGS

B1. Temporary Works

1. Construction Staging & Sequencing – Cut & Cover Bottom-Up
2. Excavation Plans & Temporary Support System
3. Diaphragm Wall / Soldier Pile + Strut / Waler Drawings
4. Dewatering System Layout & Details
5. Temporary Deck Slab (Traffic Deck), if required

B2. Permanent Works

1. Base Slab – Plan, Sections, Reinforcement
2. Side Walls – Plans, Elevations, Reinforcement
3. Roof Slab – Plans, Sections, Reinforcement
4. Construction Joints, Expansion Joints, Water-stopping System
5. Waterproofing System & Protection Layers
6. Drainage Channels, Trench Drains, Collector Drains
7. Portal Structures – Entry & Exit

C. OPEN-TO-SKY RAMP DRAWINGS (BOTTOM-UP)

1. Ramp Excavation & Temporary Support Drawings
2. Retaining Wall Drawings (RCC / RE Wall)
3. Ramp Base Slab – Plan & Reinforcement
4. Side Drains, Catch Pits, Gully Gratings
5. Crash Barriers, Parapets & Railing Details
6. Horizontal & Vertical Geometry Sheets

D. ROAD UNDER BRIDGE (RUB) – BOX PUSHING DRAWINGS

D1. General Arrangement

1. RUB GAD – Plan, Elevation, Sections
2. RUB Cross Sections (Approaches + Underpass)
3. Road Level, Rail Level / Existing Utility Level Integration (if applicable)

D2. Permanent Structure Drawings

1. RCC Box Culvert – Plan, Sections, Reinforcement Details
2. Box Segments (Cell Details) – Reinforcement Schedules
3. Cutting Edge / Nose Arrangement (Steel or RCC)
4. Wing Walls / Return Walls / Drainage Structures
5. Approach Embankment & Pavement Drawings

D3. Box Pushing Methodology Drawings

1. Pushing Platform / Launching Pad Arrangement
2. Thrust Bed & Reaction Frame Drawings
3. Jack Layout (Hydraulic Jacks + Staging + Bracing)

4. Bentonite / Lubrication System Layout
5. Overburden Protection (ESM Blocks / RCC Slab / Rail Protection Slab)
6. Shear Keys, Guide Rails & Anti-drag Details
7. Sequence of Pushing – Stage Drawings

D4. Utility, Rail / Road Integration

1. Existing Utility Diversions near RUB
2. Drainage Integration – Sumps, Wing Wall Drains, Collector Drains
3. Temporary Traffic Block Plans (if under rail/major road)

E. ROADWORK & HIGHWAY GEOMETRY DRAWINGS

1. Pavement Layer Details – Tunnel, Ramp & RUB Approaches
2. Typical Road Cross Sections in Urban Stretch
3. Super elevation & Transition Details
4. Road Marking, Signage & Delineators Layout
5. Pedestrian/Footpath Details (if applicable)

F. SERVICES & MEP FOR TUNNEL

1. Tunnel Lighting System Layout
2. Power Distribution & Cable Tray Routing
3. Tunnel Ventilation System Layout (Jet Fans / Ducts)
4. Fire Suppression System Layout (Hydrants, RIS, Extinguishers)
5. Fire Detection & Alarm System Drawings
6. Drainage Pumps, Sumps & Discharge Pipelines
7. Control Room / SCADA Layouts
8. Earthing & Lightning Protection Layouts

G. SAFETY & ITS DRAWINGS

1. CCTV Layout with Camera Positioning
2. Emergency Signage & Wayfinding Drawings
3. Emergency Communication System (SOS Phones)
4. Tunnel Safety Accessories & Road Furniture

H. UTILITY RELOCATION & PROTECTION DRAWINGS

1. Existing Utility Mapping (OFC, Water, Sewer, Gas, Electricity)
2. Utility Diversion Plan Sheets
3. Protection for Utilities Not Diverted
4. Integration with Municipal Stormwater Drains

I. ENVIRONMENTAL & EHS DRAWINGS

1. Barricading & Safety Signage Plans
2. Construction Stage Traffic Diversion Plans
3. Noise / Dust Mitigation Arrangements
4. Erosion Control & Silt Traps (During Construction)

J. LAND & RIGHT-OF-WAY DRAWINGS

1. Land Plan Schedules (L-Sections & Parcel Plans)
2. ROW Drawings – Chainage wise
3. Encroachment Removal & Relocation Plan

Schedule - J

(See Clause 10.3 (ii))

Project Completion Schedule

1. Project Completion Schedule

During Construction period, the Contractor shall comply with the requirements set forth in this Schedule-J for each of the Project Milestones and the **Scheduled Completion Date**. Within 15 (fifteen) days of the date of each Project Milestone, the Contractor shall notify the Authority of such compliance along with necessary particulars thereof.

2. Project Milestone-I

(i) Project Milestone-I shall occur on the date falling on the 192nd **[One Hundred Ninety-Two]** day from the Appointed Date (the "**Project Milestone- I**").

(ii) Prior to the occurrence of Project Milestone-I, the Contractor shall have commenced construction of the Project Road and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 10% (ten per cent) of the Contract Price.

3. Project Milestone-II

(i) Project Milestone-II shall occur on the date falling on the 328th **[Three Hundred Twenty-eighth]** day from the Appointed Date (the "**Project Milestone- II**").

(ii) Prior to the occurrence of Project Milestone II, the Contractor shall have continued with construction of the Project Road and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 35% (thirty-five per cent) of the Contract Price **and should have started construction of all bridges**

4. Project Milestone-III

(i) Project Milestone-III shall occur on the date falling on the 465th **[Four Hundred Sixty Fifth]** day from the Appointed Date (the "**Project Milestone- III**").

(ii) Prior to the occurrence of Project Milestone-III, the Contractor shall have continued with construction of the Project Road and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 70% (seventy per cent) of the Contract Price and **should have started construction of all project facilities.**

5. Scheduled Completion Date

(i) The Scheduled Completion Date shall occur on the 547th [Five Hundred Forty Seventh] day from the Appointed Date.

(ii) On or before the Scheduled Completion Date, the Contractor shall have completed construction in accordance with this Agreement.

6. Extension of time

Upon extension of any or all of the aforesaid Project Milestones or the Scheduled Completion Date, as the case may be, under and in accordance with the provisions of this Agreement, the Project Completion Schedule shall be deemed to have been amended accordingly.

Schedule - K

(See Clause 12.1 (ii))

Tests on Completion

1. Schedule for Tests

(i) The Contractor shall, no later than 30 (thirty) days prior to the likely completion of construction, notify the Authority's Engineer and the Authority of its intent to subject the Project Road to Tests, and no later than 10(ten) days prior to the actual date of Tests, furnish to the Authority's Engineer and the Authority detailed inventory and particulars of all works and equipment forming part of Works.

(ii) The Contractor shall notify the Authority's Engineer of its readiness to subject the Project Road to Tests at any time after 10 (ten) days from the date of such notice, and upon receipt of such notice, the Authority's Engineer shall, in consultation with the Contractor, determine the date and time for each Test and notify the same to the Authority who may designate its representative to witness the Tests. The Authority's Engineer shall thereupon conduct the Tests itself or cause any of the Tests to be conducted in accordance with Article 12 and this Schedule-K.

2. Tests

(i) Visual and physical test: The Authority's Engineer shall conduct a visual and physical check of construction to determine that all works and equipment forming part thereof conform to the provisions of this Agreement. The physical tests shall include [***].

(ii) Riding quality test: Riding quality of each lane of the carriageway shall be checked with the help of a Network Survey Vehicle (NSV) fitted with latest equipment and the maximum permissible roughness for purposes of this Test shall be [2,400 (two thousand four hundred)] mm for each kilometre.

(iii) Tests for bridges: All major and minor bridges shall be subjected to the rebound hammer and ultrasonic pulse velocity tests, to be conducted in accordance with the procedure described in Special Report No. 17: 1996 of the IRC Road Research Board on Nondestructive Testing Techniques, at two spots in every span, to be chosen at random by the Authority's Engineer. Bridges with a span of 15 (fifteen) metres or more shall also be subjected to load testing.

(iv) Other tests: The Authority's Engineer may require the Contractor to carry out or cause to be carried additional tests, in accordance with Good Industry Practice, for determining the compliance of the Project Road with Specifications and Standards, except tests as specified in clause 5,but shall include measuring the reflectivity of road markings and road signs; and measuring the illumination level (lux) of lighting using requisite testing equipment.

(v) Environmental audit: The Authority's Engineer shall carry out a check to determine conformity of the Project Road with the environmental requirements set forth in Applicable Laws and Applicable Permits.

(vi) Safety Audit: The Authority's Engineer shall carry out, or cause to be carried out, a safety audit to determine conformity of the Project Road with the safety requirements and Good Industry Practice.

(vii) Tunnel Specific Tests:

a. Rebound hammer tests and UPV tests for in situ concrete quality

b. Core extraction tests for critical elements (roof slab, walls, base slab)
c. Crack mapping
d. Cover meter tests for reinforcement protection
e. Watertightness test / water ponding test on base slab
f. Sump and pump testing
g. Static load test on roof slab as per MoRTH1700/IRC 112
h. Line level and alignment Check
i. Clearance envelope Check
j. Air flow test and pressure differential test
k. Noise level test
l. Smoke control Simulation test and smoke extraction test
m. Air Quality test
n. Illumination test (lux level)
o. Backup power test
p. Earth resistance test
q. Hydrostatic pressure test of firefighting pipes
r. Sprinkler / hydrant functional test
s. Fire alarm test
t. Functionality test for tunnel systems

(viii) Box Pushing under Railway related tests

a. UPV & Rebound Hammer Tests
b. Dimensional Accuracy Check (length, squareness, camber)
c. Joint Integrity Check – rubber gaskets, sealing layers
d. Crack Measurement
e. Line & Level Survey of Box
f. Overburden Deformation Monitoring
g. Thrust Bed / Launching Pad Integrity Check

(ix) Commissioning tests

a) Integrated System Testing (IST)
b) Emergency Evacuation Simulation
c) Power Failure Response Test
d) Traffic Flow Trial Run Test
e) Security, CCTV, communication checks
f) Night Visibility Test (lighting + signages)

3. Agency for conducting Tests

All Tests set forth in this Schedule-K shall be conducted by the Authority's Engineer or such other agency or person as it may specify in consultation with the Authority.

4. Completion Certificate

Upon successful completion of Tests, the Authority's Engineer shall issue the Completion Certificate in accordance with the provisions of Article 12.

5. The Authority Engineer will carry out tests with following equipment at his own cost in the presence of contractor's representative.

Sr. No.	Key metrics of Asset	Equipment to be used	Frequency of condition survey
1	Surface defects of pavement	Network Survey Vehicle (NSV)	At least twice a year (As per survey months defined for the state basis rainy season)

2	Roughness of pavement	Network Survey Vehicle (NSV)	At least twice a year (As per survey months defined for the state basis rainy season)
3	Strength of pavement	Falling Weight Deflectometer (FWD)	At least once a year
4	Bridges	Mobile Bridge Inspection Unit (MBU)	At least twice a year (As per survey months defined for the state basis rainy season)
5	Road signs	Retro-reflectometer	At least twice a year (As per survey months defined for the state basis rainy season)

The first testing with the help of NSV shall be conducted at the time of issue of Completion Certificate.

Schedule - L

(See Clause 12.2)

Completion Certificate

1 I, …….. (Name of the Authority's Engineer), acting as the Authority's Engineer, under and in accordance with the Agreement dated……(the "**Agreement**"), for Construction of 3-Lane Bi-Directional Road Underpass on Bellary Road between Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU) Campus, Bengaluru on EPC Mode (the "**Project Road**") on Engineering, Procurement and Construction (EPC) basis through……(Name of Contractor), hereby certify that the Tests in accordance with Article 12 of the Agreement have been successfully undertaken to determine compliance of the Project Road with the provisions of the Agreement, and I am satisfied that the Project Road can be safely and reliably placed in service of the Users thereof.

2 It is certified that, in terms of the aforesaid Agreement, all works forming part of Project Road have been completed, and the Project Road is hereby declared fit for entry into operation on this the …… day of …… 20… , Scheduled Completed Date for which was the …… day of ……20…..

SIGNED, SEALED AND DELIVERED
For and on behalf of the Authority's Engineer by:
(Signature)
(Name)

(Designation) (Address)

Schedule - M

(See Clauses 14.6, 15.2 and 19.7)

Payment Reduction for Non-Compliance

1. Payment reduction for non-compliance with the Maintenance Requirements

(i) Monthly lump sum payments for maintenance shall be reduced in the case of non-compliance with the Maintenance Requirements set forth in Schedule E.

(ii) Any deduction made on account of non-compliance with the Maintenance Requirements shall not be paid even after compliance subsequently. The deductions shall continue to be made every month until compliance is done.

(iii) The Authority's Engineer shall calculate the amount of payment reduction on the basis of weightage in percentage assigned to non-conforming items as given in Paragraph 2.

2. Percentage reductions in lump sum payments on monthly basis

(i) The following percentages shall govern the payment reduction:

S. No.	Item/Defect/Deficiency	Percentage
(a)	**Carriageway/Pavement/ tunnel**	
(i)	Potholes, cracks, other surface defects	15%
(ii)	Repairs of Edges, Rutting	5%
(iii)	Water seepage into lining or poor drainage	5%
(iv)	Non-functional lighting,	5%
(v)	Non-functional jet fans	5%
(vi)	Non-functional CCTV	5%
(vii)	Faulty signage	5%
(viii)	Faulty barriers	5%
(ix)	Faulty emergency egress	5%
(x)	Faulty drainage	5%
(x)	Non-functional Firefighting/ detection system	10%
(xi)	Non-functional rapid breakdown response protocols, including vehicle arrestor systems, emergency lanes, and dedicated rescue teams (Two-hour clearance time) per day per side	10%
(b)	**Road, Embankment, Cuttings, Shoulders**	
(i)	Edge drop, inadequate cross fall, undulations, settlement, potholes, ponding, obstructions	10%

(ii)	Deficient slopes, raincuts, disturbed pitching, vegetation growth, pruning of trees	5%
(c)	**Bridges and Culverts**	
(i)	Desilting, cleaning. vegetation growth, damaged pitching, flooring, parapets, wearing course, footpaths, any damage to foundations	20%
(ii)	Any Defects in superstructures, bearings and sub-structures	10%
(iii)	Painting, repairs/replacement kerbs, railings, parapets, guideposts/crash barriers	5%
(d)	**Roadside Drains**	
(i)	Cleaning and repair of drains	5%
(e)	**Road Furniture**	
(i)	Cleaning, painting, replacement of road signs, delineators, road markings, 200 m/km/5th km stones	5%
(f)	**Miscellaneous Items**	
(i)	Removal of dead animals, broken down/accidented vehicles, fallen trees, road blockades or malfunctioning of mobile crane	10%
(ii)	Any other Defects in accordance with paragraph 1.	5%
(g)	**Defects in Other Project Facilities**	5%

(ii) The amount to be deducted from monthly lump-sum payment for non- compliance of particular item shall be calculated as under:

Where,

$$R = {}^{P}/_{100} \times (M1 \text{ or } M2) \times {}^{L1}/_{L}$$

P= Percentage of particular item/Defect/deficiency for deduction

M1= Monthly lump-sum payment in accordance para 1.2 above of this Schedule

M2= Monthly lump-sum payment in accordance para 1.2 above of this Schedule

L1= Non-complying length L = Total length of the road,

R= Reduction (the amount to be deducted for non-compliance for a particular item/Defect/deficiency

The total amount of reduction shall be arrived at by summation of reductions for such items/Defects/deficiency or non-compliance.

For any Defect in a part of one kilometer, the non-conforming length shall be taken as one kilometer.

Schedule - N

(See Clause 18.1 (i))

Selection of Authority's Engineer

1. Selection of Authority's Engineer

(i) The provisions of the Model Request for Proposal for Selection of Technical Consultants, issued by the Ministry of Finance in May 2009, or any substitute thereof shall apply for selection of an experienced firm to discharge the functions and duties of an Authority's Engineer.

(ii) In the event of termination of the Technical Consultants appointed in accordance with the provisions of Paragraph 1.1, the Authority shall appoint another firm of Technical Consultants forthwith and may engage a government-owned entity in accordance with the provisions of Paragraph 3 of this Schedule-N.

2. Terms of Reference

The Terms of Reference for the Authority's Engineer (the "**TOR**") shall substantially conform with Annex 1 to this Schedule N.

3. Appointment of Government entity as Authority's Engineer

Notwithstanding anything to the contrary contained in this Schedule, the Authority may in its discretion appoint a government-owned entity as the Authority's Engineer; provided that such entity shall be a body corporate having as one of its primary functions the provision of consulting, advisory and supervisory services for engineering projects; provided further that a government-owned entity which is owned or controlled by the Authority shall not be eligible for appointment as Authority's Engineer.

Annex – I

(Schedule - N)

Terms of Reference for Authority's Engineer

1. Scope

(i) These Terms of Reference (the "**TOR**") for the Authority's Engineer are being specified pursuant to the EPC Agreement dated ..... (the "**Agreement**), which has been entered into between the Bangalore Development Authority (BDA) (the "**Authority**") and ..... (the "**Contractor**")# for Construction of 3-Lane Bi-Directional Road Underpass on Bellary Road between Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU) Campus, Bengaluru on EPC Mode, and a copy of which is annexed hereto and marked as Annex-A to form part of this TOR.

- In case the bid of Authority's Engineer is invited simultaneously with the bid of EPC project, then the status of bidding of EPC project only to be indicated

(ii) The TOR shall apply to construction and maintenance of the Project Road.

2. Definitions and interpretation

(i) The words and expressions beginning with or in capital letters and not defined herein but defined in the Agreement shall have, unless repugnant to the context, the meaning respectively assigned to them in the Agreement.

(ii) References to Articles, Clauses and Schedules in this TOR shall, except where the context otherwise requires, be deemed to be references to the Articles, Clauses and Schedules of the Agreement, and references to Paragraphs shall be deemed to be references to Paragraphs of this TOR.

(iii) The rules of interpretation stated in Article 1 of the Agreement shall apply, mutatis mutandis, to this TOR.

3. General

(i) The Authority's Engineer shall discharge its duties in a fair, impartial and efficient manner, consistent with the highest standards of professional integrity and Good Industry Practice.

(ii) The Authority's Engineer shall perform the duties and exercise the authority in accordance with the provisions of this Agreement, but subject to obtaining prior written approval of the Authority before determining:

(a) any Time Extension;

(b) any additional cost to be paid by the Authority to the Contractor;

(c) the Termination Payment; or

(d) issuance of Completion Certificate or

(e) any other matter which is not specified in (a), (b), (c) or (d) above and which creates a financial liability on either Party.

(iii) The Authority's Engineer shall submit regular periodic reports, at least once every month, to the Authority in respect of its duties and functions under this Agreement. Such reports shall be submitted by the Authority's Engineer within 10 (ten) days of the beginning of every month.

(iv) The Authority's Engineer shall ensure that NSV survey shall be conducted at the following intervals: (13.11.2019)

a) Before start of the work,

b) Before issue of provisional/final completion certificate,

c) Every 6 months after completion of work

The NSV report shall be uploaded on online portal (if any)

(v) The Authority's Engineer in consultation with the Authority shall update online Portal of the Authority (if any), and also ensure to submit Monthly and Quarterly Progress Report along with Strip Chart. Such updations shall be done on the last date of every month/ quarter and if required, on a weekly basis as advised by the Authority. Monthly invoices towards services of the Authority's Engineer shall not be admitted for payment in case of non-compliance of the above.

(vi) The Authority's Engineer shall inform the Contractor of any delegation of its duties and responsibilities to its suitably qualified and experienced personnel; provided, however, that it shall not delegate the authority to refer any matter for the Authority's prior approval in accordance with the provisions of Clause 18.2.

(vii) The Authority's Engineer shall aid and advise the Authority on any proposal for Change of Scope under Article 13.

(viii) In the event of any disagreement between the Parties regarding the meaning, scope and nature re of Good Industry Practice, as set forth in any provision of the Agreement, the Authority's Engineer shall specify such meaning, scope and nature by issuing a reasoned written statement relying on good industry practice and authentic literature.

4. Construction Period

(i) During the Construction Period, the Authority's Engineer shall review and approve the Drawings furnished by the Contractor along with supporting data, including the geo-technical and hydrological investigations, characteristics of materials from borrow areas and quarry sites, topographical surveys, and the recommendations of the Safety Consultant in accordance with the provisions of Clause 10.1 (vi). The Authority's Engineer shall complete such review and approval and send its observations to the Authority and the Contractor within 15 (fifteen) days of receipt of such Drawings; provided, however that in case of a Major Bridge or Structure, the aforesaid period of 15 (fifteen) days may be extended upto 30 (thirty) days. In particular, such comments shall specify the conformity or otherwise of such Drawings with the Scope of the Project and Specifications and Standards.

(ii) The Authority's Engineer shall review and approve any revised Drawings sent to it by the Contractor and furnish its comments within 10 (ten) days of receiving such Drawings.

(iii) The Authority's Engineer shall review and approve the Quality Assurance Plan submitted by the Contractor and shall convey its comments to the Contractor within a period of 21 (twenty one) days stating the modifications, if any, required thereto.

(iv) The Authority's Engineer shall complete the review and approve of the methodology proposed to be adopted by the Contractor for executing the Works, and convey its comments to the Contractor within a period of 10 (ten) days from the date of receipt of the proposed methodology from the Contractor.

(v) The Authority's Engineer shall grant written approval to the Contractor, where necessary,

for interruption and diversion of the flow of traffic in the existing lane(s) of the Project Road for purposes of maintenance during the Construction Period in accordance with the provisions of Clause 10.4.

(vi) The Authority's Engineer shall review the monthly progress report furnished by the Contractor and send its comments thereon to the Authority and the Contractor within 7 (seven) days of receipt of such report.

(vii) The Authority's Engineer shall inspect the Construction Works and the Project Road and shall submit a monthly Inspection Report bringing out the results of inspections and the remedial action taken by the Contractor in respect of Defects or deficiencies. In particular, the Authority's Engineer shall include in its Inspection Report, the compliance of the recommendations made by the Safety Consultant.

(viii) The Authority's Engineer shall conduct the pre-construction review of manufacturer's test reports and standard samples of manufactured Materials, and such other Materials as the Authority's Engineer may require.

(ix) For determining that the Works conform to Specifications and Standards, the Authority's Engineer shall require the Contractor to carry out, or cause to be carried out, tests at such time and frequency and in such manner as specified in the Agreement and in accordance with Good Industry Practice for quality management. For purposes of this Paragraph 4 (ix), the tests specified in the MoRTH Specifications for Road and respective Indian Road Congress Standards/Guidelines/Manuals, together with any other Indian/International Standards mentioned therein including any modifications/substitutions thereof shall be deemed to be test confirming to Good Industry Practice for quality management.

(x) The Authority's Engineer shall witness all the quality control tests carried out by the Contractor at its site laboratory/main laboratory/field/plants. These includes tests for all materials, mixes, products, etc. Authority's Engineer shall also witness all tests of finished products like bearing in the manufacturer's laboratory as mandate in respective standards. Authority's Engineer will also conduct review of quality control documents in respect of factory manufactured materials/finished products, etc. as per IRC:SP:112

(xi) The timing of tests referred to in Paragraph 4 (ix), and the criteria for acceptance/ rejection of their results shall be determined by the Authority's Engineer in accordance with the MoRTH specifications for Road & Bridge works and respective Indian Road Congress Standards/Guidelines/Manuals together with any other Indian/International Standards referred thereto. The tests shall be undertaken on a random sample basis and shall be in addition to, and independent of, the tests that may be carried out by the Contractor for its own quality assurance in accordance with Good Industry Practice.

(xii) In the event that results of any tests conducted under Clause 11.10 establish any Defects or deficiencies in the Works, the Authority's Engineer shall require the Contractor to carry out remedial measures.

(xiii) The Authority's Engineer may instruct the Contractor to execute any work which is urgently required for the safety of the Project Road, whether because of an accident, unforeseeable event or otherwise; provided that in case of any work required on account of a Force Majeure Event, the provisions of Clause 21.6 shall apply.

(xiv) In the event that the Contractor fails to achieve any of the Project Milestones, the Authority's Engineer shall undertake a review of the progress of construction and identify potential delays, if any. If the Authority's Engineer shall determine that completion of the

Project Road is not feasible within the time specified in the Agreement, it shall require the Contractor to indicate within 15 (fifteen) days the steps proposed to be taken to expedite progress, and the period within which the Project Completion Date shall be achieved. Upon receipt of a report from the Contractor, the Authority's Engineer shall review the same and send its comments to the Authority and the Contractor forthwith.

(xv) The Authority's Engineer shall obtain from the Contractor a copy of all the Contractor's quality control records and documents before the Completion Certificate is issued pursuant to Clause 12.2.

(xvi) Authority's Engineer may recommend to the Authority suspension of the whole or part of the Works if the work threatens the safety of the Users and pedestrians. After the Contractor has carried out remedial measure, the Authority's Engineer shall inspect such remedial measures forthwith and make a report to the Authority recommending whether or not the suspension hereunder may be revoked.

(xvii) In the event that the Contractor carries out any remedial measures to secure the safety of suspended works and Users, and requires the Authority's Engineer to inspect such works, the Authority's Engineer shall inspect the suspended works within 3 (three) days of receiving such notice, and make a report to the Authority forthwith, recommending whether or not such suspension may be revoked by the Authority.

(xviii) The Authority's Engineer shall carry out, or cause to be carried out, all the Tests specified in Schedule-K and issue a Completion Certificate, as the case may be. For carrying out its functions under this Paragraph 4 (xviii) and all matters incidental thereto, the Authority's Engineer shall act under and in accordance with the provisions of Article 12 and Schedule-K.

5. Maintenance Period

(i) The Authority's Engineer shall aid and advise the Contractor in the preparation of its monthly Maintenance Programme and for this purpose carry out a joint monthly inspection with the Contractor.

(ii) The Authority's Engineer shall undertake regular inspections, at least once every month, to evaluate compliance with the Maintenance Requirements and submit a Maintenance Inspection Report to the Authority and the Contractor.

(iii) The Authority's Engineer shall specify the tests, if any, that the Contractor shall carry out, or cause to be carried out, for the purpose of determining that the Project Road is in conformity with the Maintenance Requirements. It shall monitor and review the results of such tests and the remedial measures, if any, taken by the Contractor in this behalf.

(iv) In respect of any defect or deficiency referred to in Paragraph 3 of Schedule- E, the Authority's Engineer shall, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Specifications and Standards and shall also specify the time limit for repair or rectification of any deviation or deterioration beyond the permissible limit.

(v) The Authority's Engineer shall examine the request of the Contractor for closure of any lane(s) of the Project Road for undertaking maintenance/repair thereof, and shall grant permission with such modifications, as it may deem necessary, within 5 (five) days of receiving a request from the Contractor. Upon expiry of the permitted period of closure,

the Authority's Engineer shall monitor the reopening of such lane(s), and in case of delay, determine the Damages payable by the Contractor to the Authority under Clause 14.5.

6. Determination of costs and time

(i) The Authority's Engineer shall determine the costs, and/or their reasonableness, that are required to be determined by it under the Agreement.

(ii) The Authority's Engineer shall determine the period of Time Extension that is required to be determined by it under the Agreement.

(iii) The Authority's Engineer shall consult each Party in every case of determination in accordance with the provisions of Clause 18.5.

7. Payments

(i) The Authority's Engineer shall withhold payments for the affected works for which the Contractor fails to revise and resubmit the Drawings to the Authority's Engineer in accordance with the provisions of Clause 10.2 (iv) (d).

(ii) Authority's Engineer shall -

(a) within 10 (ten) days of receipt of the Stage Payment Statement from the Contractor pursuant to Clause 19.4, determine the amount due to the Contractor and recommend the release of 90 (ninety) percent of the amount so determined as part payment, pending issue of the Interim Payment Certificate; and

(b) within 15 (fifteen) days of the receipt of the Stage Payment Statement referred to in Clause 19.4, deliver to the Authority and the Contractor an Interim Payment Certificate certifying the amount due and payable to the Contractor, after adjustments in accordance with the provisions of Clause 19.10.

(iii) The Authority's Engineer shall, within 15 (fifteen) days of receipt of the Monthly Maintenance Statement from the Contractor pursuant to Clause 19.6, verify the Contractor's monthly statement and certify the amount to be paid to the Contractor in accordance with the provisions of the Agreement.

(iv) The Authority's Engineer shall certify final payment within 30 (thirty) days of the receipt of the final payment statement of Maintenance in accordance with the provisions of Clause 19.16.

8. Other duties and functions

The Authority's Engineer shall perform all other duties and functions as specified in the Agreement.

9. Miscellaneous

(i) A copy of all communications, comments, instructions, Drawings or Documents sent by the Authority's Engineer to the Contractor pursuant to this TOR, and a copy of all the test results with comments of the Authority's Engineer thereon, shall be furnished by the Authority's Engineer to the Authority forthwith.

(ii) The Authority's Engineer shall retain at least one copy each of all Drawings and Documents received by it, including 'as-built' Drawings, and keep them in its safe custody.

(iii) Within 90 (ninety) days of the Project Completion Date, the Authority's Engineer shall obtain a complete set of as-built Drawings, in 2 (two) hard copies and in micro film form

or in such other medium as may be acceptable to the Authority, reflecting the Project Road as actually designed, engineered and constructed, including an as- built survey illustrating the layout of the Project Road and setback lines, if any, of the buildings and structures forming part of Project Facilities; and shall hand them over to the Authority against receipt thereof.

(iv) The Authority's Engineer, if called upon by the Authority or the Contractor or both, shall mediate and assist the Parties in arriving at an amicable settlement of any Dispute between the Parties.

(v) The Authority's Engineer shall inform the Authority and the Contractor of any event of Contractor's Default within one week of its occurrence.

Schedule - O

(See Clauses 19.4 (i), 19.6 (i), and 19.8 (i))

Forms of Payment Statements

1. Stage Payment Statement for Works

The Stage Payment Statement for Works shall state:

(a) the estimated amount for the Works executed in accordance with Clause 19.3 (i) subsequent to the last claim;

(b) amounts reflecting adjustments in price for the aforesaid claim;

(c) the estimated amount of each Change of Scope Order executed subsequent to the last claim;

(d) amounts reflecting adjustment in price, if any, for (c) above in accordance with the provisions of Clause 13.2 (iii) (a);

(e) total of (a), (b), (c) and (d) above;

(f) Deductions:

i. Any amount to be deducted in accordance with the provisions of the Agreement except taxes;

ii. Any amount towards deduction of taxes; and

iii. Total of (i) and (ii) above.

(g) Net claim: (e) – (f) (iii);

(h) The amounts received by the Contractor upto the last claim:

i. For the Works executed (excluding Change of Scope orders);

ii. For Change of Scope Orders, and

iii. Taxes deducted

2. Monthly Maintenance Payment Statement

The monthly Statement for Maintenance Payment shall state:

(a) the monthly payment admissible in accordance with the provisions of the Agreement;

(b) the deductions for maintenance work not done;

(c) net payment for maintenance due, (a) minus (b);

(d) amounts reflecting adjustments in price under Clause 19.12; and

(e) amount towards deduction of taxes

3. Contractor's claim for Damages

Note: The Contractor shall submit its claims in a form acceptable to the Authority.

Schedule - P

(See Clause 20.1)

Insurance

1. Insurance during Construction Period

(i) The Contractor shall effect and maintain at its own cost, from the Appointed Date till the date of issue of the Completion Certificate, the following insurances for any loss or damage occurring on account of Non Political Event of Force Majeure, malicious act, accidental damage, explosion, fire and terrorism:

(a) insurance of Works, Plant and Materials and an additional sum of [15 (fifteen)] per cent of such replacement cost to cover any additional costs of and incidental to the rectification of loss or damage including professional fees and the cost of demolishing and removing any part of the Works and of removing debris of whatsoever nature; and

(b) Insurance for the Contractor's equipment and Documents brought onto the Site by the Contractor, for a sum sufficient to provide for their replacement at the Site.

(ii) The insurance under sub para (a) and (b) of paragraph 1(i) above shall cover the Authority and the Contractor against all loss or damage from any cause arising under paragraph 1.1 other than risks which are not insurable at commercial terms.

2. Insurance for Contractor's Defects Liability

The Contractor shall effect and maintain insurance cover of not less than 15% of the Contract Price for the Works from the date of issue of the Completion Certificate until the end of the Defects Liability Period for any loss or damage for which the Contractor is liable and which arises from a cause occurring prior to the issue of the Completion Certificate. The Contractor shall also maintain other insurances for maximum sums as may be required under the Applicable Laws and in accordance with Good Industry Practice.

3. Insurance against injury to persons and damage to property

The Contractor shall insure against its liability for any loss, damage, death or bodily injury, or damage to any property (except things insured under Paragraphs 1 and 2 of this Schedule or to any person (except persons insured under Clause 20.9), which may arise out of the Contractor's performance of this Agreement. This insurance shall be for a limit per occurrence of not less than the amount stated below with no limit on the number of occurrences.

The insurance cover shall be not less than: Rs. [*****]

The insurance shall be extended to cover liability for all loss and damage to the Authority's property arising out of the Contractor’s performance of this Agreement excluding:

the Authority's right to have the construction works executed on, over, under, in or through any land, and to occupy this land for the Works; and damage which is an unavoidable result of the Contractor's obligations to execute the Works.

4. Insurance to be in joint names

The insurance under paragraphs 1 to 3 above shall be in the joint names of the Contractor and the Authority.

Schedule-Q

(See Clause 14.10)

Tests on Completion of Maintenance Period

1. Riding Quality test:

Riding quality test: Riding quality of each lane of the carriageway shall be checked with the help of a calibrated bump integrator and the maximum permissible roughness for purposes of this Test shall be [2,400 (two thousand and four hundred only)] mm for each kilometre.

2. Visual and physical test:

The Authority's Engineer shall conduct a visual and physical check of construction to determine that all works and equipment forming part thereof conform to the provisions of this Agreement. The physical tests shall include measurement of cracking, rutting, stripping and potholes and shall be as per the requirement of maintenance mentioned in Schedule-E.

3. Tunnel concrete condition tests:

The Authority's Engineer shall conduct tests of construction to determine that all works and equipment forming part thereof conform to the provisions of this Agreement.

Tunnel Ventilation Systems

a) Jet Fan Functional Testing
b) Air Velocity Tests across tunnel
c) Smoke Extraction Test (Cold smoke or simulation)
d) Noise Level Test

Lighting System

a) Lux Level Measurement (day, night)
b) Emergency Lighting Test (battery backup duration test)
c) Automatic switching test

Power Supply & Electrical Systems

a) Earthing Resistance Test
b) Insulation Resistance Test for cables
c) DG Set Load Test
d) UPS Capacity Test
e) Circuit breaker & protection relay testing

Fire & Life Safety Systems

a) Firefighting Pump Test – pressure, flowrate
b) Hydrant, RIS, sprinkler functional test
c) Fire Alarm System test
d) PA system (Public address) test
e) Fire extinguishers – pressure & expiry audit
f) Emergency signage audit

SCADA, ITS & Emergency Systems

a) CCTV functionality test
b) Video analytics / AID test (if provided)
c) Tunnel communication test (SOS, Radio, GSM repeater)
d) SCADA integration test
e) Control Room system redundancy check

DRAINAGE & WATER CONTROL SYSTEM TESTS

a) Drainage Network Testing
b) Drain Flow Test using artificial water flow
c) Silt Trap & Catchpit functionality check

d) Backflow valve testing
e) CCTV inspection of drains (internal camera inspection)

Sump & Pump System Tests

a) Pump discharge capacity test
b) Automatic start/stop test
c) Redundancy test of standby pumps
d) Float switch / water level controller test

ENVIRONMENTAL & HABITABILITY TESTS

a) Air Quality & Ventilation Performance
b) CO level testing
c) NOx testing
d) PM2.5 and PM10 measurement
e) Ventilation response test under peak traffic

Noise & Vibration Monitoring

a) Ambient Noise Measurement
b) Vibration levels at portal and internal zones

Illumination & Visibility

a) Visibility distance measurement
b) Retro-reflectivity test for signboards

Schedule-R

(See Clause 14.10)

Taking Over Certificate

I, …….. (Name and designation of the Authority's Representative) under and in accordance with the Agreement dated …… (the "**Agreement**"), for Construction of 3-Lane Bi-Directional Road Underpass on Bellary Road between Hebbal Junction and University of Agriculture Sciences (UAS) Staff Quarters via Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU) Campus, Bengaluru on EPC MODE on Engineering, Procurement and Construction (EPC) basis through …… (Name of Contractor), hereby certify that the Tests on completion of Maintenance Period in accordance with Article 14 of the Agreement have been successfully undertaken to determine compliance of the Project Road with the provisions of the Agreement and I hereby certify that the Authority has taken over the Project Road from the Contractor on this day.....

SIGNED, SEALED AND DELIVERED
(Signature)

(Name and designation of Authority's Representative)

(Address)

******* End of the Document *******